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ABSTRACT

This individualized, self-paced course for independent study in plumbing was adapted from military curriculum materials for use in vocational education. The course provides the theory to accompany on-the-job training in the plumbing trade. It provides basic information on job safety and tools, waste systems, and water supply systems and fixtures. The course is organized in three volumes. Volume 1, Career Orientation, Supervision, and Resource Management, contains chapters on job safety and job tools and equipment. Volume 2, Waste Systems, contains chapters on sewage systems and waste disposal; structural openings, building drains, stacks, and vents; roughing-in vents and waste lines; measuring, cutting, threading, and assembling pipe; and inspecting and maintaining waste systems. The final volume, Water Supply Systems and Fixtures, contains seven chapters covering water supply systems and pipe assembling; roughing-in water supplies and installing fixtures; copper tubing and brass pipe; insulation and winterization of plumbing; water heaters, dishwashers, steam kettles, sinks, and auxiliary plumbing equipment; preventive maintenance and corrosion control; and fire protection and lawn sprinkler systems. Each chapter is organized around criterion learning objectives. A numbered objective is followed by text and an exercise with answers provided. Each volume is accompanied by a volume review exercise containing from 107 to 114 multiple choice questions coded to the learning objectives, without answers. (KC)

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# MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

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# Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

# Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

**Project Staff:**

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

# What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

# How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

**EAST CENTRAL**
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

**MIDWEST**
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1515 West Sixth Ave.
Stillwater, OK 74704
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**SOUTHEAST**
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## PLUMBING SPECIALIST

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# PLUMBING SPECIALIST

Correspondence Course 3-2

**Developed by:**

United States Air Force

**Development and Review Dates**

Unknown

**Occupational Area:**

Building and Construction

| **Cost:** | **Print Pages:** |
|---|---|
| $6.25 | 309 |

**Availability:**

Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

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**Suggested Background:**

None

**Target Audiences:**

Grades 10-adult

**Organization of Materials:**

Criterion objectives, text, questions, answers, volume review exercises

**Type of Instruction:**

Individualized, self-paced

| **Type of Materials:** | | | **No. of Pages:** | **Average Completion Time:** |
|---|---|---|---|---|
| Volume 1 | – | *Career Orientation, Supervision, and Resource Management* | 50 | Flexible |
| | | Volume Review Exercises | 8 | |
| Volume 2 | – | *Waste Systems* | 93 | Flexible |
| | | Volume Review Exercises | 12 | |
| Volume 3 | – | *Water Supply Systems and Fixtures* | 134 | Flexible |
| | | Volume Review Exercises | 12 | |

**Supplementary Materials Required:**

None

Expires July 1, 1978

**Course Description:**

This course provides the theory to accompany on-the-job training in the plumbing trade. It provides basic information on job safety and tools, waste systems, and water supply systems and fixtures.

Volume 1 – *Career Orientation, Supervision, and Resource Management* contains five chapters, three of which contain extensive information on military procedures and forms. The remaining chapters are suitable for vocational courses.

- Chapter 2 – *Job Safety* covers tools and equipment, gases, heating devices and hot materials, gas burners and flammables, electrical hazards and grounds, moving heavy objectives, and work platform safety.
- Chapter 3 – *Job Tools and Equipment* describes the uses of various plumbing tools, and the care of tools and shop equipment.

Volume 2 – *Waste Systems* contains five chapters suitable for classroom use.

- Chapter 1 – *Sewer Systems and Waste Disposal* contains information on exterior sewer systems, installing building sewers, and individual waste systems.
- Chapter 2 – *Structural Openings, Building Drains, Stacks, and Vents* covers cutting openings, building waste systems, stacks and vents.
- Chapter 3 – *Roughing-In Vents and Waste Lines* discusses waste rough-in for lavatories, urinals, bathtubs and showers, water closets, floor and roof drains.
- Chapter 4 – *Measuring, Cutting, Threading, and Assembling Pipe* explains the use of cast-iron soil pipe, manual procedures for steel pipe, the use of power tools, and procedures for copper, brass, plastic and chromium pipe.
- Chapter 5 – *Inspecting and Maintaining Waste Systems* discusses test specifications, repairing waste systems, grease traps, sanitary sewers, building drains, and individual waste systems.

Volume 3 – *Water Supply Systems and Fixtures* contains seven chapters suitable for vocational courses.

- Chapter 1 – *Water Supply Systems and Pipe Assembling* gives background on water supply systems, installing systems, maintaining systems, temporary water mains, and sweat soldering.
- Chapter 2 – *Roughing-In Water Supplies and Installing Fixtures* discusses roughing-in water supplies, installing various fixtures, testing systems and recovering plumbing equipment.
- Chapter 3 – *Copper Tubing and Brass Pipe* explains fabrication of copper tubing and brass and copper pipe.
- Chapter 4 – *Insulation and Winterization of Plumbing* discusses the selection of proper insulation for pipes and winterization of plumbing systems.
- Chapter 5 – *Water Heaters, Dishwashers, Steam Kettles, Sinks, and Auxiliary Plumbing Equipment* covers installation and maintenance of this equipment.
- Chapter 6 – *Preventive Maintenance and Corrosion Control* includes inspection, maintenance procedures and repairs.
- Chapter 7 – *Fire Protection and Lawn Sprinkler Systems* discusses various kinds of interior and exterior fire protection devices and lawn sprinkler systems.

Each chapter is organized around criterion learning objectives. A numbered objective is followed by text and an exercise. The answers to the exercises are provided in the back of each volume and students are encouraged to reread the text sections if they miss an exercise, then continue on to the next learning objective. Each volume is accompanied by a volume review exercise containing from 107 to 114 multiple choice questions coded to the learning objectives. No answers are given. This course is designed for student self-study to accompany laboratory or on-the-job training.

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CDC 55255

# PLUMBING SPECIALIST

(AFSC 55255)

## Volume 1

*Career Orientation, Supervision, and Resource Management*

Proficimus More Irretenti

Extension Course Institute

Air University

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PREPARED BY
DEPARTMENT OF CIVIL ENGINEERING TRAINING
USAF SCHOOL OF APPLIED AEROSPACE SCIENCES (ATC)
SHEPPARD AIR FORCE BASE, TEXAS

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EXTENSION COURSE INSTITUTE, GUNTER AIR FORCE STATION, ALABAMA

THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL
OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES
ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

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# Preface

THIS VOLUME of CDC 55255, *Plumbing Specialist*, provides you with general information about Civil Engineering organization, career progression, communications security, publications, job safety, job tools and equipment, supervision and training, resource management, and project planning.

As a plumbing specialist, you install and maintain many different types of plumbing systems. By carefully studying the three volumes of this course and the illustrations presented, you acquire the knowledge necessary to perform your assigned tasks.

Code numbers appearing on figures are for use by preparing agency only.

If you have any questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvements, send them to Tech Tng Cen/TTOX, Sheppard AFB TX 76311. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have any questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behavorial Objective Exercises, Volume Review Exercises, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 27 hours (9 points).

Material in this volume is technically accurate, adequate, and current as of October 1975.

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# MODIFICATIONS

[illegible] pages 1-25 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

CHAPTER 2

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# Job Safety

AS A PLUMBING specialist, you are a craftsman. The mark of a craftsman can be seen by the excellence of the product he makes and also by the safe manner and methods he uses in producing it. A master of his trade seldom gets hurt. He knows his tools and equipment and keeps them in proper working condition. He understands the dangers of his working environment and never takes unnecessary chances. He studies the rules of safety and has the wisdom to apply them as he works. Don't for one moment think that your supervisor will think more of you if, to save a little time, you ignore the rules of safety. He will know you for what you are—foolish or immature. That statement in plain, simple language is "To break safety rules is to be a fool."

Base safety people know beyond a shadow of a doubt that unsafe working habits will eventually create an accident. Recently an operator lost an arm because he failed to turn the power off while adjusting a power machine. His loose sleeve was caught in the rotating machinery. Signs were posted in the shop, and on the machine that hurt him the sign read "STOP MACHINE BEFORE ADJUSTING."

Develop in your mind the attitude of following and obeying safety rules. They were developed first for your protection and second for the protection of the equipment you operate. Always operate your equipment according to the step-by-step procedures given in technical orders. If there are no TOs on the equipment, follow the manufacturer's operating and maintenance instructions. This chapter covers tools and equipment safety, gases, heating devices and hot materials, gas barriers and flammables, electrical hazards and grounds, moving heavy objects, and work platforms.

## 2-1. Tools and Equipment Safety

Many people are under the impression that handtools are simple devices that can be used by anyone with little or no training. This idea is untrue. Handtools are precision instruments capable of performing many jobs when used properly. To be safe in handling handtools, you must have tools of good quality that are kept sharp and in good repair.

Accidents are costly. Money spent on materials and manpower for recovering from costly accidents is wasted. It cannot be redeemed. Even if no personal injury is involved, materials damaged by unsafe acts are costly to the Air Force.

Injury and material loss are only two of the many factors which are involved when an accident happens. Other factors are that the efficiency of the organization is affected and morale is affected; if enough accidents happen, that could impair the good relation between an organization and the community.

A standard dictionary defines the word "accident" as "an event that takes place without foresight or expectation." This definition means that with adequate foresight most accidents can be prevented. Only 2 percent of all accidents are caused by natural phenomena such as lightning; 10 percent are caused by physical hazards; and 88 percent of the accidents are caused by unsafe acts of people, as shown in figure 2-1, causes of accidents. The publication you use for safety precautions is AFR 127-101, *Accident Prevention Handbook*.

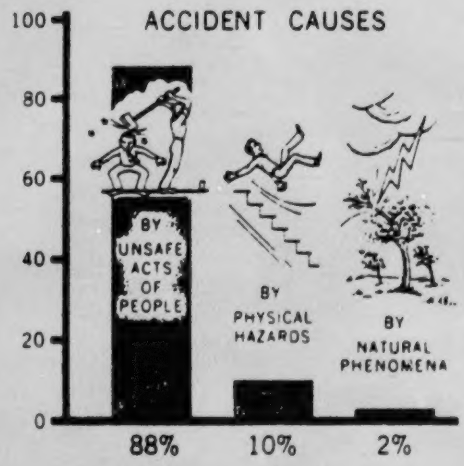

Figure 2-1. Causes of accidents

Much of the equipment you use to perform your duties is located in the shop. Oil on the floor can cause you to slip and hit your head on a hard object. Someone said, "A dirty or disorderly shop breeds accidents and discontent." Let's look at work area safety before looking at tools and equipment safety.

**024. From a list of statements relative to work area safety practices, check those that are true.**

Your work area may contain many potential hazards if you fail to follow the safety rules established for your protection. The safety rules will make you conscious of some of the things you should, or should not, do to perform your job safely.

**Work Area Safety Practices.** Failure to keep your work area clean and orderly can result in both major and minor accidents. Broken bones, cuts, gouges, bruises, burns, and many other injuries can result from poor housekeeping. The prevention of these injuries is simply to practice good housekeeping. Here are 12 important items to consider as safety practices for your work area (and also your living area):

(1) Keep all floors and walkways clean, dry, and free from spilled oil, fuel, or other contaminants. If fuel, oil, or grease is spilled, clean it up immediately.

(2) Make sure your shop or other area is adequately ventilated at all times. Vapors from fuels, oils, gases, and some types of acids are injurious to your health.

(3) Keep all working areas well lighted, if at all possible. You cannot work efficiently and safely without sufficient light. Check the lighting system frequently and report or replace burned-out lamps and fuses.

(4) Don't leave tools scattered about on floors, workstands, or other places. Always use the cabinets and boxes provided for tool storage.

(5) Don't clutter your work area with unnecessary equipment. If you do not intend to use an item, store it in a safe place.

(6) Keep all ropes, chains, cables, hoses, and electrical cords properly stored when not in use.

(7) Provide suitable waste containers and make sure that waste is promptly put into the proper container. Mark each container for the material for which it is to be used.

(8) Use extra care in disposing of scrap metal, tubing wire, glass, etc. Make sure that all parts of the materials are well inside the waste container. The sharp edges of these materials can cut and tear your skin as well as your clothes.

(9) Inspect all electrical cables and equipment for frayed wiring insulation, exposed contacts, and condition of switch handles and other controls.

(10) Do not horseplay with your coworkers. You are no longer in grade school. Horseplay can cause anger which can develop into serious accidents.

(11) Inspect your shop frequently for protruding nails, bolt ends, and other sharp points that can cause injury. Also make sure that broken windows and door glasses are replaced promptly and that the broken glass is properly disposed of.

(12) Insure that water fountains, lunch areas, and clothing lockers are clean and sanitary. Illness caused by contaminated water and food can often become more serious than most accidents.

**Exercises (024):**

Check the following statements with a checkmark (✓) if they reflect good work area safety practices.

____ 1. Prodding a fellow worker in the ribs is OK if not done too often.
____ 2. Frayed 110-volt wires can be used if bare wires are not exposed.
____ 3. Since you will use a portable drill in 4 hours, leave it on the work bench.
____ 4. Close all shop windows in the winter to save on the heating bill.
____ 5. When a fuse keeps burning out in a certain circuit, place a penny behind it.
____ 6. Leave your tools in the places where you will use them.
____ 7. A clean shop is an inefficient shop.
____ 8. Assure that broken windows are replaced promptly.

**025. From a list of practices relative to the general use of handtools, identify those that are not safety practices.**

**Handtools Safety.** Poor maintenance and the improper use of common handtools results in many accidents which could be avoided if proper safety procedures are followed. As you cover specific tools later in this chapter, you will learn safety precautions about individual tools. This objective covers safety procedures about handtools in general. These practices are as follows:

(1) Keep tools sharp.

(2) Keep tools in their proper place.

(3) Replace handles that become splintered or loose.

(4) Dress mushroom heads on cold chisels, punches, drift pins, etc.

(5) Protect the edges of cutting tools with a sheath or by storing them separately from other tools.

(6) Select a box-end wrench or a socket in preference to an open end or an adjustable wrench as the former are less likely to slip. To help prevent slippage, always pull the wrench toward you.

(7) Wear goggles or face shields when there is a possibility of flying chips, sparks, etc.

(8) Hold small items that are being worked on in a vise.

(9) Never use a tool for anything other than what it is intended to be used for: i.e., using a hammer handle

for a pry bar, using a wrench for a hammer, and using a knife for a screwdriver.

(10) Use screwdrivers for what they are designed—to drive and remove screws. Keep the blades ground and shaped properly at all times. Select the proper type and size of screwdriver for the job. Never hold an object in one hand while working on it with a screwdriver. Place it in a vise.

(11) Use files and rasps with handles that are designed for them. Without the proper handle, a file or rasp is dangerous, because it is easy for the tang to injure the palm of your hand.

(12) Keep chisels and punches clean and sharp, because it is easy for a dull or dirty tool to slip and injure you.

**Exercises (025):**

Place an X in the spaces which are not safety practices.

____ 1. Use a screwdriver as a wedge.
____ 2. Use a box-end wrench in preference to an open-end wrench.
____ 3. Use an adjustable wrench in preference to an open-end wrench.
____ 4. Wear goggles when chiseling a hole in sewer pipe.
____ 5. Hammer a rusted pipe union with a pipe wrench.
____ 6. Keep tools sharp.
____ 7. Sharpen screwdriver to a knife edge to cut wood.

**026. Given situations, distinguish between those that contribute to unsafe use of power equipment and those that contribute to safe use.**

**Power Equipment Safety.** You can be severely injured by coming in contact with moving machine parts. Although the Air Force has prescribed standards for safety in the use of machines, you must use common sense as you work with and around power equipment. Since machines are developed or changed frequently, you must be able to apply general safety rules to specific machines or specific uses of power machines. Some of the general rules that apply to equipment safety follow:

(1) Do not wear jewelry, loose clothing, long sleeves, or gloves while operating machinery.

(2) Use brushes to remove chips and metal particles. Do not use your hands.

(3) Where the possibility of flying particles exists, wear goggles or a face shield.

(4) Do not remove or block a machine guard while the machine is in operation.

(5) You must be authorized in writing before you can operate a machine.

(6) Do not leave machinery operating unattended.

(7) Do not clean, lubricate, adjust, or maintain machinery while it is in motion.

(8) Operate machines within recommended speeds.

(9) Inspect a machine before operating it.

(10) Electrically operated machines will be grounded.

**Exercises (026):**

From the following situations, place a checkmark (✓) if they follow safety rules. Place an (X) in the blank if they are unsafe.

____ 1. Inspect shop machines.
____ 2. Machines operated with motors of less than 2 horsepower require no ground.
____ 3. Brush off metal cuttings from machines with gloves.
____ 4. Use a faceshield when grinding metal.
____ 5. To facilitate lubrication, grease a machine during operation.
____ 6. Remove ring and wrist watch during machinery operation.
____ 7. Do not leave machine operating unattended even for 5 minutes.

## 2-2. Gases Safety

Since your job description states that you connect pipe sections by welding and using hot lead and that you attach fittings to pipe by soldering and sweating, you must be aware of safety rules for the compressed gases you may use—namely, oxygen, acetylene, and propane. The rules we cover in this chapter are general. As we cover specific uses of the equipment in later chapters, specific safety rules will be covered.

**027. From random statements, select those that contribute to safe handling, use, and storage of compressed gases.**

**Safety Rules for Oxygen, Acetylene, and Propane Cylinders.** These compressed gases are used for welding, brazing, soldering, and sweating. The following safety rules apply to the storage, moving, or use of these gases:

(1) Never drop a cylinder or allow it to fall.

(2) Never bump a cylinder or otherwise handle it roughly.

(3) Never lay an acetylene cylinder on its side. In addition to acetylene, the tank also contains an absorber, such as fuller's earth, and acetone to absorb the acetylene, which will get into the regulator and valves if the tank is placed on its side. Also, safety plugs in the bottom of the tank will pass harmlessly into the floor if the cylinder is standing up when they blow out.

(4) Never allow oil or grease to come into contact with oxygen; specifically, never direct a jet of oxygen at an oil-soaked surface. Spontaneous combustion may result.

(5) Never lay an oxygen cylinder on its side. The top of the cylinder carries the safety plug. If it blows

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while the cylinder is on its side, the exhaust pressure released will propel the cylinder like a rocket.

(6) Never use oil, grease, or any lubricant on a torch.

(7) Never hang a torch or hoses on regulators or cylinder valves.

(8) Never use matches for lighting a torch, as your hand may be seriously burned as a result. Use a friction igniter, a suitable pilot light, or a length of twisted paper.

(9) Never light the torch from hot metal when working in a confined space. Accumulated fumes can flare or explode.

(10) Always wear goggles when using flammable gases.

(11) Never block yourself from the cylinders when you are working; make sure that you can get to them easily and quickly from your working position.

(12) Never store cylinders in direct sunlight or near heaters.

(13) A valve clogged with ice may be thawed with warm water; however, never use a flame or boiling water for this purpose.

(14) Never test for acetylene leaks with a flame because of the danger of a flareback and a cylinder fire. Use soapy water, instead.

(15) Always open valves slowly.

(16) Always keep the special wrench used to turn acetylene on and off near the valve so that the valve can be turned off quickly in an emergency.

(17) Never hammer or beat on a valve; furthermore, do not attempt to adjust a valve or a gauge which does not work.

(18) Replace protective caps on the cylinders whenever gauges have been removed.

**Exercises (027):**

From the following statements related to compressed gases used for welding, soldering, and sweating, check (√) those that contribute to safety.

____ 1. Handle cylinders gently.
____ 2. Position acetylene cylinders horizontally during use.
____ 3. Never oil oxygen cylinder regulator valves.
____ 4. Light the torch with a match.
____ 5. Wear goggles when welding.
____ 6. You may store full cylinders in the yard.
____ 7. Tap valves lightly with a wrench to open them.
____ 8. Thaw a frozen valve with warm water.

**028. Given statements relative to health hazards of the plumber, distinguish between those that are true and those that are false.**

**Toxic Substances.** As a plumber you will come in contact with gases and other substances that can be harmful to you, both internally and externally. You must be aware of safety precautions when you work in explosive or toxic gaseous areas. For example, you may strike a match in a sewer manhole and cause an explosion. You may inhale toxic vapors for a short period of time and damage your lungs. Long-term inhalation of noxious gases usually results in absorption and transport of toxic materials within the body and can silently damage organs such as liver and kidney. Some of the toxic areas that can be dangerous to you are sewers, welding areas, and areas where there are paint fumes and vapors from many solvents.

**Sewer Areas.** You have to be extremely careful as you work around sewer areas, because you can be hurt physically, you may be infected by disease, or you may be injured by the sewer gases.

**Physical injuries.** To prevent physical injuries to personnel during sewer maintenance, you should observe the following safety rules which are taken from AFM 85-14, Appendix E:

(1) Remove and replace heavy manhole covers carefully and only with the proper tools. Heavy covers involve hazards of finger, wrist, and foot injuries during removal and replacement. After removal, lay the cover flat on the ground at least 2 feet away from the open manhole.

(2) Descend into manholes cautiously to guard against slippery, loose, corroded, broken, or otherwise defective steps or rungs. Remedy such defects immediately, together with any cracks or breaks in the manhole wall.

(3) Wear an approved safety belt with attached lifeline tested before each use when entering deep sewers. At least two men will stand by outside the manhole to handle the lifeline in case of emergency. Extra lengths of rope must be readily available.

(4) Assign a trained supervisor to direct the cleaning and maintenance of sewers, alerting subordinate personnel to all hazards and to sound precautions against them. The supervisor will be trained and equipped to administer first-aid medical treatment.

(5) Erect barriers and signs at a suitable distance from open manholes to warn traffic coming from any direction that men are at work.

*Body infections:* Safety precautions that apply to body infections, as taken from AFM 85-14, are as follows:

(1) Treat all cuts, skin abrasions, and similar injuries promptly. Around sewage plants, the smallest cut or scratch is potentially dangerous and should be cleaned and treated immediately with 2-percent tincture of iodine solution.

(2) See a doctor for all but clearly minor injuries.

(3) Know first-aid procedures. First-aid training must be provided for all personnel.

(4) To prevent waterborne diseases, it is prudent to keep your immunization status current.

(5) Keep fingers out of nose, mouth, and eyes, because the hands carry most infections in this field of work.

(6) After work, before eating, and at other convenient times, wash hands thoroughly with plenty of soap and hot water. Keep the fingernails short and remove all dirt as often as possible with a nail file or stiff, soapy brush. Do not brush fingers when they are raw and sore.

(7) Keep hands out of sewage, sludge, and other filth as much as possible: if such contact is unavoidable, wear rubber gloves wherever practicable.

*Safety equipment.* When you work around sewage areas, the following safety equipment should be available:

(1) Emergency first-aid kits to treat minor cuts, burns, skin abrasions, and similar wounds.

(2) Rubber gloves for workers to use in cleaning clogged sludge pumps, and handling screenings, sewage, grit, or other filth. Such protection is particularly important when the hands are chapped or burned or the skin broken by a wound.

(3) Coveralls or a complete change of work clothes for working hours.

(4) Rubbers to keep the shoes clean and dry in sludge pumping or other operations. General use of boots and rubbers is recommended.

*Sewer Gas.* The principal gas hazards are accumulations of sewer gas and its mixture with other gases or air, which may injure maintenance and operation personnel through explosion or by asphyxiation as a result of oxygen deficiency. The term "sewer gas" is generally applied to the mixture of gases in sewers and manholes containing abnormally high percentages of carbon dioxide; varying amounts of methane, hydrogen, hydrogen sulfide; and low percentages of oxygen. Such mixtures sometimes accumulate in sewers, especially those laid on nearly flat grades, from the fermentation or decomposition of settled organic matter. The term "sewer gas" is misleading, because it is a mixture subject to wide variations. The actual hazard exists in the explosive amount of methane or in oxygen deficiency.

Do not smoke or use open flames in and around open sewer manholes. If you have to have light, use only lights that are approved by the National Board of Fire Underwriters for hazardous atmospheres. Ventilate sewers by allowing air to enter or if necessary pump air into the system.

**Welding Areas.** During the welding process, some metals can produce a fume, a condensed vapor of metal. The primary hazards of welding are metal fume fever which causes chest congestion. You can also injure your eyes due to ultraviolet light. As you weld or work in a welding area, be certain to wear approved welding goggles and if necessary, an approved air purifying respirator.

**Paints.** Two types of paints are of primary health concern. Polyurethane paints containing diisocyanates can induce a permanent allergic reaction similar to asthma. This compound is also irritating to skin and lungs. Lead-based paints, rarely used today, can result in systemic heavy metal poisoning. All oil-based paints are of some concern because of the solvents which evaporate as the paint dries. If you work in freshly painted areas, provide fresh air into the structure. You must use an approved chemical cartridge respirator if you paint. The National Institute of Occupational Safety and Health (NIOSH) approves respirators.

**Solvents.** A solvent, as used in this text, is a liquid that is used to dissolve a solid that is toxic. Many toxic liquids are used in paint and cleaning solvents. Among the most toxic solvents are benzene, wood alcohol, and carbon tetrachloride. The use of benzene and carbon tetrachloride is prohibited in the USAF without specific approval for each issue by the Director of Base Medical Services. These substances are injurious to the human body in varying degrees. Whereas the body can stand a small amount of these poisonous materials for short periods of time, overexposure to them may have harmful effects. The effect can be irritation to the membranes in your nose. It can cause you to have a headache, dizziness, loss of appetite, nausea, fatigue, and irritation to the skin. These poisons can also cause damage to the liver and kidney. Solvents come in spray cans and other types of containers.

To prevent the health hazards of toxic solvents, you must use a common sense approach. Avoid unnecessary contact with these hazardous materials. Read the instructions on the containers and follow them. Adhere to safety rules established by your supervisor. Be sure that ventilation is adequate. Wear goggles, the proper type of respirator, or protective clothing if conditions require it. Wash hands and face thoroughly at the end of the day or before eating. If you develop symptoms of overexposure, get out of the environment and notify your supervisor.

**Exercises (028):**

In the following blanks, place a "T" if the statement is true and an "F" if the statement is false.

____ 1. Toxic solvents can cause irritation to your skin.
____ 2. Smoking is permitted 3 feet from a sewer manhole.
____ 3. Sewer gas is usually a mixture of many gases.
____ 4. Do not use gloves when cleaning a sludge pump.
____ 5. Toxic gases can damage your lungs.
____ 6. Wear an approved safety belt when entering a deep sewer.
____ 7. If an injury is more than very minor, call a doctor.
____ 8. All Air Force sewers are safe after the manhole cover has been removed for 5 minutes.

____ 9. A light used in a sewer must be approved by the medical department.
____ 10. Welding areas and freshly painted areas must be well ventilated before you work there.

## 2-3. Heating Devices and Hot Materials Safety

The plumbing specialist uses heating devices to melt materials so that he can fabricate cast-iron and copper pipe in a plumbing system. A typical heating device is the propane melting furnace used to melt lead in a lead pot. You must exercise care when you use this equipment.

**029. Given situations concerning melting lead and using compounds and caustics, think through the problems and specify solutions.**

**Melting Furnace.** The plumber uses a melting furnace for melting lead and keeping it at the proper temperature for pouring joints. The melting furnace is an extremely valuable tool, but very dangerous, and must be handled with extreme caution to prevent accidents.

The best and most efficient type of melting furnace uses liquefied petroleum gas as a fuel. This furnace consists of a burner and valve assembly which mounts directly on a portable propane gas tank. The tank is detachable and can be recharged with fuel. A propane furnace lights instantly and burns with a high temperature blue flame. This furnace should not be subjected to rough treatment, since there is always the danger of an explosion from leakage of gas at the connections and valves. You should make a thorough inspection for leaks before lighting the furnace. To light the furnace, fold or twist tightly a lighted length of paper under the burner orifice of the burner assembly as shown in figure 2-2, lighting a melting furnace. Carefully open the fuel regulating valve until the burner lights. If the valve is opened too much or too rapidly, the pressure of the escaping gas may extinguish the lighter flame. If this should happen, close the fuel valve immediately and then relight the paper before reopening the valve.

A safe worker will always wear asbestos gloves and use a shield for protection when lighting a furnace, as there is the possibility of receiving burns from a flame or small explosion as the fuel ignites.

**Molten Metals.** The melting pot, shown in figure 2-2, is used to melt lead for pouring into cast-iron-pipe joints. The temperature of boiling water is 212° F. Boiling water will blister your skin. Can you imagine what melted lead at 900° F. will do when it touches your skin? The melted lead can burn you more severely than the flame of the furnace. Personal injuries to others must also be avoided when carrying molten lead in a ladle, as it is easy to bump into another worker or a visitor and spill the lead on them. Another precaution to take when working with molten lead is to make certain all equipment is free of water, as a little water will make lead pop and jump. If it lands on you, it can cause a severe burn. Lead vapors are very dangerous if you inhale them for long periods. Be sure of adequate ventilation when you heat lead.

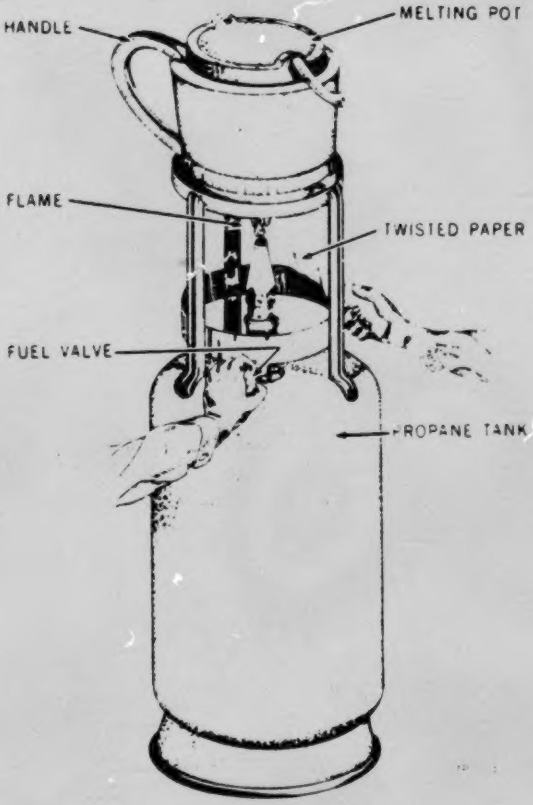

Figure 2-2. Lighting a melting furnace.

CAUTION: Although most plumbing shops have phased out the gasoline melting furnace, there are still a few in use. In addition to the precautions described for the propane furnace, other safety precautions are required for the gasoline furnace. If you should use this furnace, read the manufacturer's instructions thoroughly and follow those instructions exactly.

**Compounds and Caustics.** Most of the compounds and caustics you find about civil engineering shops are dangerous when heated. Do not heat any of these materials until you have read the labels on the containers. After you are thoroughly familiar with the properties of these materials, you may use them as prescribed by the manufacturer. If it is necessary for you to work with caustics and cleaning compounds, be certain that the ventilation is adequate. Most caustics

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develop heat when added to water. Caustics, even in mild solutions, can burn your skin. If you feel a burning sensation on your hands or other portions of your body, flush them with water as soon as possible.

**Exercises (029):**

1. Situation No. 1. On Monday morning your supervisor assigned you to pour 48 joints of 4-inch cast-iron soil pipe. He assigned two apprentice plumbers to help you. The following equipment was available to you in the shop:
   Propane melting furnace.
   Gasoline melting furnace.
   Welding equipment.
   *a.* What equipment would you use?

   *b.* Why?

2. Situation No. 2. Your supervisor assigned you to remove oil and grease from about 100 feet of 2-inch pipe located outside the shop. A number of cleaning compounds were available in the shop.
   *a.* What is your first step?

   *b.* How do you do the job?

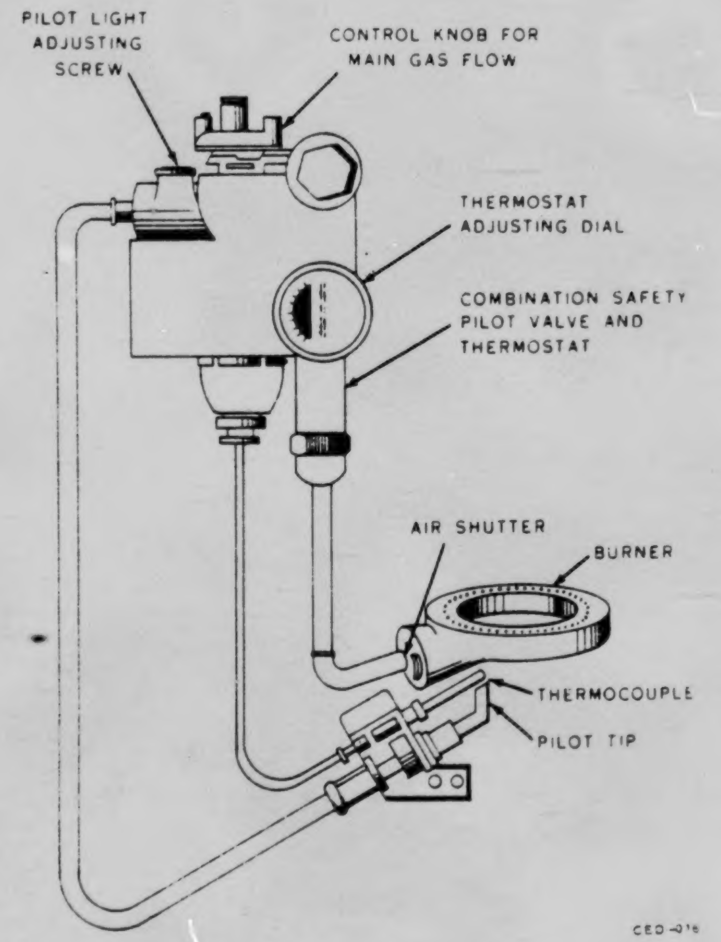

PILOT LIGHT ADJUSTING SCREW
CONTROL KNOB FOR MAIN GAS FLOW
THERMOSTAT ADJUSTING DIAL
COMBINATION SAFETY PILOT VALVE AND THERMOSTAT
AIR SHUTTER
BURNER
THERMOCOUPLE
PILOT TIP
CED-016

Figure 2-3. Automatic safety controls and burner assembly.

## 2-4. Gas Burners and Flammables Safety

As a plumber, you may be called on to maintain gas burners that are an integral part of water heaters, cook stoves, or building furnaces. You may also come in contact with flammables, such as natural gas, propane, gasoline, heating oil, and other petroleum products. Safety precautions must become a part of your makeup as you deal with gas burners and flammables because if you neglect safety, you can injure yourself or burn a building down.

**030. From a list of safety precautions, distinguish between those that are safe and those unsafe when checking gas burners, water heaters, or gas leaks.**

**Gas Burners.** Figure 2-3, automatic safety controls and burner assembly, illustrates typical safety controls used for gas burners. Although this particular control is for a water heater, the principles of operation are the same for ovens, furnaces, and other gas burners. You should know the operating principles of safety controls so that you are aware when they are not operating properly.

Assume that you have closed the main gas valve using the control knob shown at the top of figure 2-3. Wait approximately 5 minutes before checking out the unit. To check it out, make sure the thermostat is opening and closing. You do this by turning the thermostat adjusting dial back and forth on the low temperature end of the scale until you hear a click. The clicking sound tells you that the thermostat is opening properly. After this test, set the thermostat adjusting dial to normal (140°) for ordinary use. Turn the main gas control knob to open and light the pilot. The safety controls automatically close the gas to the main burner when the pilot light is out.

As long as the thermocouple is heated by the pilot light, it will keep the main burner valve open but when the pilot goes out the thermocouple cools off, causing the gas valve to the main burner to close. The thermostat extends into the hot water tank. It also controls the gas going to the main burner. The thermostat is controlled by the temperature of the water inside the tank.

After the pilot light has been burning for about 5 minutes, adjust it so it will have a soft blue flame about three-fourths of an inch high.

Water heaters made by different companies have different patents for their heating units and automatic controls. As a plumber you will be required to make certain adjustments located in different positions on the heating units. Follow the step-by-step procedure given on the metal service plate mounted on each water heater and always keep in mind: for proper efficiency of any type water heater, it must be properly installed and adjusted.

**Safety of Water Heaters.** Every type of hot water tank should be safeguarded against the possibility of an explosion that can be caused by superheated water due to the failure of an automatic cutoff or the neglect of not turning off a manually controlled heater. Few people realize that a single pound of water, changed into steam, under certain pressure and temperature conditions, can release over 2 million foot-pounds of explosive energy. This is more than could be released by a pound of nitroglycerine and is more than enough force to shatter a building. A safety valve is required to be installed on the outlet side of piping to the water heater. The valve must be within 3 inches of the top of the heater. The type valve preferred is the temperature and pressure safety valve. This valve is set at 125 pounds working pressure and 210°F.

**Testing for Gas Leaks.** After the gasoline has been properly installed and before the system is put into service, it must be tested for leaks. Leakage of gas is not only wasteful but also constitutes a serious hazard. Therefore, check a gas system more closely than a water system.

In testing a gas system, some element, such as peppermint, is added to the gas to give it an odor. Possible leaks can then be detected, but frequently even this type of test may allow the gas to leak for a long time before it is detected. Do not test for gas leaks with matches or open flames.

The simplest test for leaks at joints or valves is the application of soapsuds to the suspected surface. Bubbles will appear on the pipe surface if there is any indication of a leak.

If a leak is detected, it should be repaired immediately. If the leak is a defective pipe or fitting, it should be replaced. If it is a leaky valve, it must be repaired.

**Exercises (030):**

If the following precautions are safe, place an "S" in the blank space. If they are unsafe, use a "U."

____ 1. Use a length of twisted paper to test for gas leaks.

____ 2. A simple test for gas leaks is soapsuds.

____ 3. When the pilot light goes out, the main gas valve closes automatically.

____ 4. A thermostat controls the main burner on an oven.

____ 5. To light a water heater, follow the rules you learned in the CDC.

**031. From given information, match the type of flammable material with the class of fire and state the extinguishing agent to use on various types of fires.**

**Flammables.** Materials that burn readily or quickly are called flammable. These materials may be solids, liquids, or gases. As a plumbing specialist, you will work in areas containing flammable materials. When flammable materials are combined with heat and oxygen in certain proportions, a fire results. Although

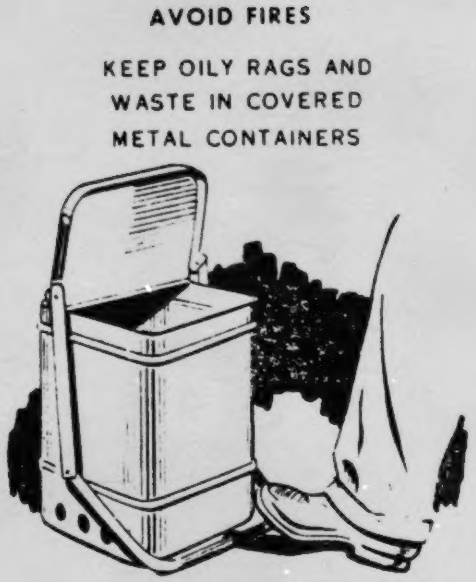


Figure 2-4. Fire prevention at work.

firefighting is the prime responsibility of the fire department, it is your duty to prevent fires and to help in extinguishing them if they do start.

Good housekeeping is essential in the effective prevention of fires. If you let rubbish, waste, dust, and other residue accumulate, they are a source of fire. Oily rags, for example, can ignite by spontaneous combustion. You can prevent fires of this type by storing oily rags in a covered metal container, as shown in figure 2-4, fire prevention at work.

Another serious fire hazard is the accumulation of fuel vapors, gases, paint vapors, and other items of this nature. To eliminate this type of hazard, keep your shop clean and well ventilated. Prevent fires whenever you can, but also know something about the four classes of fires and something about how to fight them.

**Classes of Fires.** You can extinguish fires in each of the four classes by the use of a particular action or extinguishing agent. Some fire extinguishers do not work satisfactorily on all classes of fires. Water, for example, may cause an oil fire to spread rather than extinguish the fire.

*Class A fires* are fires occurring in wood, clothing, paper, rags, and other items of this nature. This type of fire can usually be handled effectively with water. Water provides the cooling and quenching effect necessary to extinguish class A fires. You may also use the soda-acid type extinguisher on this class of fire. Another type of extinguisher you can use on class A fires is the foam [illegible]. You may also use foam on class B fires.

*Class B fires* are those occurring in flammable liquids such as gasoline, fuel oil, lube oil, grease, some solvents, paints, etc. The agents required for extinguishing this type of fire are those which will dilute or eliminate the air by blanketing the surface of the fire. This action creates a smothering effect. The types of fire extinguishers for use on class B fires are foam, carbon dioxide ($CO_2$), and dry chemical. The dry chemical units contain a dry powder, usually sodium bicarbonate, and an activating agent of $CO_2$ or nitrogen gas. The dry chemical extinguisher is also used on class C and class D fires.

*Class C fires* are fires in electrical equipment and facilities. The extinguishing agent for this type of fire must be a nonconductor of electricity and must provide a smothering effect. The dry chemical extinguisher is used for this purpose.

*Class D fires* occur in combustible metals such as magnesium, potassium, powdered aluminum, zinc, sodium, titanium, ziroconium and lithium. The extinguishing agent for this type fire must be a dry-powdered compound. The powdered compound must create a smothering effect.

In the case of any fire, there are certain actions required of the individual who discovers the fire. His first action should be to sound the alarm and alert all personnel. Second, the installation fire department must be called and given exact directions to the location of the fire. These first two actions must be taken quickly, and after they have been accomplished, the personnel available should apply the most effective measures available to extinguish or to contain the fire. When assigned to a new section, you should locate the fire extinguishers in the area. Also determine the types of extinguisher that are available and how to operate them. This information is usually printed on the fire extinguisher.

**Exercises (031):**

1. Match the class of fire in column B with the flammable material in column A by placing the class letter in the appropriate blank.

| *Column A*<br>*Flammable Material* | *Column B*<br>*Class of Fire* |
|---|---|
| ___ a. Magnesium. | Class A |
| ___ b. Electrical equipment. | Class B |
| ___ c. Paper and rags. | Class C |
| ___ d. Gasoline and grease. | Class D |

2. Name three types of extinguishing agents that are used on paper and wood fires.

3. What three types of extinguishers are used on gasoline and oil fires?

4. What type of extinguisher is used on class C and class D fires?

## 2-5. Electrical Hazards and Grounds

Each year, scores of workmen have been injured on the job because of neglect or because of not knowing that a dangerous situation existed. A plumber using an ungrounded electrical drill was severely injured when he fell off a ladder. The plumber grabbed a moist water pipe as he was drilling a hole in a wall. From his hospital bed he told this story. As he touched the pipe, he received a severe electrical shock that passed from his right hand, through his body near his heart, and to his left hand which contacted the pipe. Although the voltage was only 110, the jolt frightened him. He fell sideways on a sawhorse, and the body of the drill hit him on the shoulder. This plumber was off duty for 3 weeks. He stated that it could have killed him. A 110-volt charge of electricity is dangerous, especially when you are working on damp or wet pavements and grounds. It can kill you; so be aware of electrical hazards and precautions as you use electrical powered tools.

**032. From typical situations distinguish between those that reflect safe and those that reflect unsafe procedures for tools powered by electricity.**

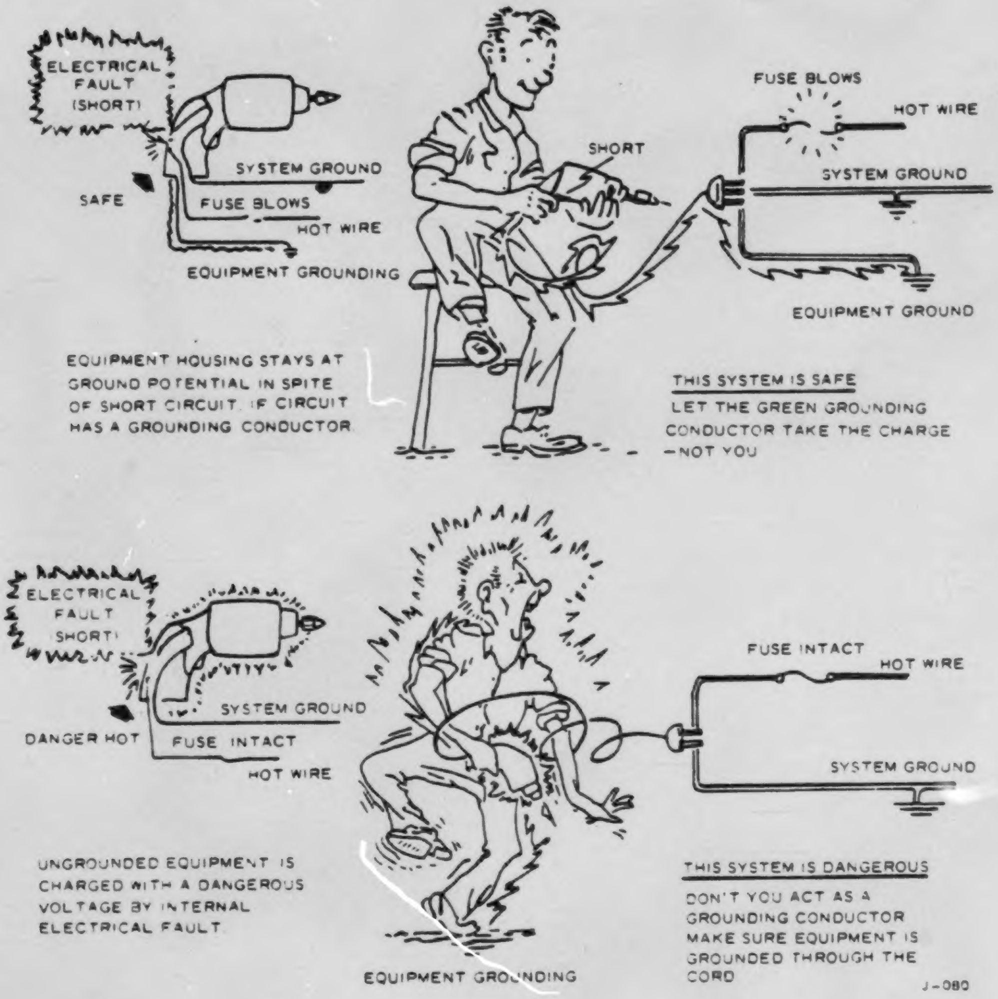

ELECTRICAL FAULT (SHORT)
SAFE
SYSTEM GROUND
FUSE BLOWS
HOT WIRE
EQUIPMENT GROUNDING
EQUIPMENT HOUSING STAYS AT GROUND POTENTIAL IN SPITE OF SHORT CIRCUIT, IF CIRCUIT HAS A GROUNDING CONDUCTOR
SHORT
FUSE BLOWS
HOT WIRE
SYSTEM GROUND
EQUIPMENT GROUND
THIS SYSTEM IS SAFE
LET THE GREEN GROUNDING CONDUCTOR TAKE THE CHARGE —NOT YOU
ELECTRICAL FAULT SHORT
DANGER HOT
SYSTEM GROUND
FUSE INTACT
HOT WIRE
UNGROUNDED EQUIPMENT IS CHARGED WITH A DANGEROUS VOLTAGE BY INTERNAL ELECTRICAL FAULT
EQUIPMENT GROUNDING
FUSE INTACT
HOT WIRE
SYSTEM GROUND
THIS SYSTEM IS DANGEROUS
DON'T YOU ACT AS A GROUNDING CONDUCTOR MAKE SURE EQUIPMENT IS GROUNDED THROUGH THE CORD
J-080

Figure 2-5. How equipment grounding works.

**Electrical Hazards and Precautions.** As a plumber, you will use a variety of tools powered by electricity because of convenience, speed, and efficiency. However, because of their source of power, they are hazardous unless you know how to safeguard against the hazards. The main hazards are from fire and shock caused from improper grounding and from cord abuse.

*Fire hazards.* Electric-powered handtools are a potential source of ignition for a fire if used near flammable materials or in explosive atmospheres, unless they are of the explosion-proof type. You must be continuously aware of this hazard as you work in areas which have dust and fumes.

*Improper grounding.* When you use power tools, check them to make certain that they have three-wire cords. The extension cord must also have three wires and be plugged into a grounded receptacle. Figure 2-5, how equipment grounding works, shows how a drill motor equipped with a three-wire cord can protect the operator by providing a low-resistance path to ground for the current from a defective tool. It also shows what can happen to you with equipment that is improperly grounded.

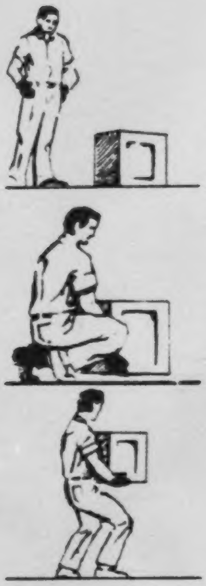
*Cord abuse.* It is important to protect the cord on your power equipment. This is also true of the extension cord. The conductors in the cord, the insulation on the cord, and the devices (plugs) must be protected if you are to have safe operation. Scraping, kinking, or stretching, as well as exposure to grease and oil, will damage power tool cords or extension cords. Use heavy-duty plugs which clamp to the cord. Do NOT jerk on the cord to unplug the unit from a receptacle. Jerking the cord can damage the cord or cause the connection in the plug to become loose and cause a short circuit.

**Exercise (032):**

1. Check each of the following situations as "S" for safe or "U" for unsafe procedures for electric powered tools.

*S or U* *Situations*

____ *a.* Using a 2-wire extension cord.
____ *b.* Jerking plug from receptacle.
____ *c.* Ventilating area subject to petroleum vapors.
____ *d.* Operating electric motor in a dust-filled room.
____ *e.* Using a heavy duty plug which clamps to cord.



LIFT THIS WAY

1. Check weight and size. A bulky, awkward load can cause more strain than a compact heavier one.
2. Plant your feet firmly, well apart, and squat down.
3. Watch out for sharp edges. Get a good grip.
4. Keep your back as straight as you can. Lift slowly (don't jerk) by pushing up with your legs.
5. Don't twist your body with the load. Shift your feet.

Figure 2-6. Safe lifting procedures.

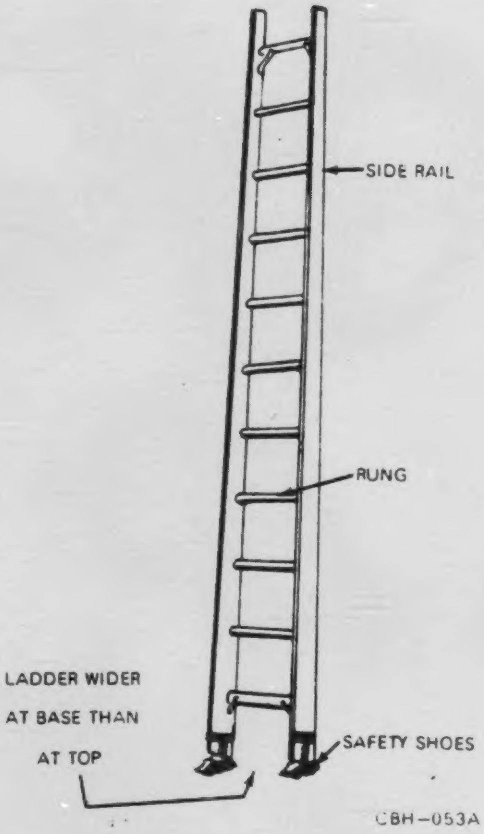


Figure 2-7. The single ladder.

**033. From situations indicating safe and unsafe operation of electrical power tools, distinguish between the safe and unsafe practices.**

**Safe Operation of Electrical Power Tools.** Following is a list of precautions to take when you use electric power tools:

*a.* Inspect the equipment, especially the external wiring, before you use it.

*b.* Use safety glasses or face shields where chips or dust could fly or tools could break.

*c.* Do not wear loose gloves or loose clothing while using rotating equipment.

*d.* Exchange accessories with the power off and the cord unplugged. Remove guard if necessary.

*e.* The guard must be in place before starting the tool.

*f.* Do not wear rings, metal rimmed glasses, watches, or other metallic objects when working with electrical tools.

*g.* If you use equipment in damp locations, stand on a rubber mat and wear rubber gloves.

*h.* Be certain the tool is properly grounded.

*i.* Check the operating instructions prior to operating electrical tools. On large equipment these instructions are usually located on a data plate which is attached to the equipment. On smaller, portable equipment, go to the manufacturer's manual to find instructions.

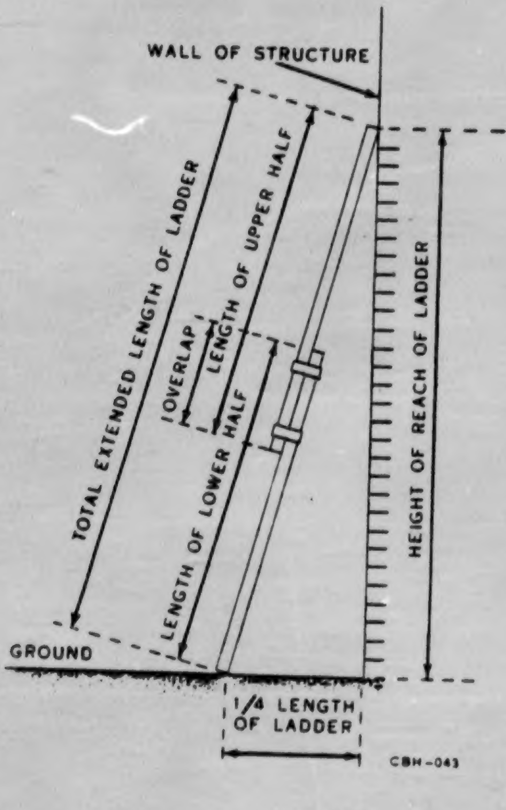


Figure 2-8. The extension ladder.

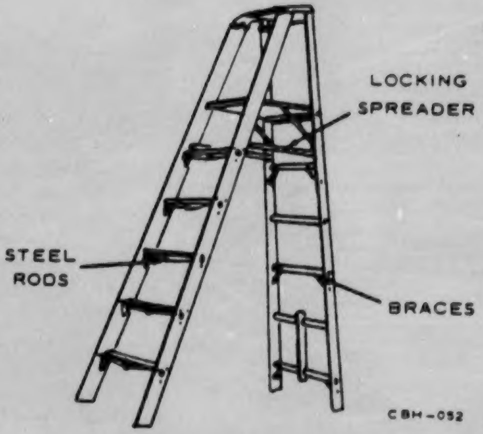


Figure 2-9. A step ladder.

*j.* Operate tools in accordance with manufacturer's instructions.

**Exercise (033):**

1. Place a check (√) in the blanks for the situations which are safe and an X in those that are unsafe.

*(√) or X* *Situations*

____ *a.* Tools operated on 110-volts need not be grounded.

____ *b.* Read operating instructions before operating an electric tool.

____ *c.* Never operate an electric tool in damp locations.

____ *d.* Inspect equipment before you use it.

____ *e.* Remove jewelry when operating electrical tools.

## 2-6. Moving Heavy Objects

The *Accident Prevention Handbook,* AFR 127-101, states that physical differences make it impracticable to set up lifting limits for workers. In your career field, it is often necessary to move materials which weigh 50 to 200 pounds. Don't be like the airman who lifted two sacks of cement and walked 60 feet with them. He was showing off—showing his buddies how strong he was. He ended up with a hernia, a reprimand, lost time, and an unfavorable mark against his unit.

Use commonsense when it comes to moving heavy objects. If it is too heavy or cumbersome for you to lift, get a buddy to help you. If that isn't satisfactory, use a mechanical device designed for handling heavy objects. If you decide that you can lift a heavy or cumbersome load, use the proper body lifting position to do it.

**034. Differentiate between safe and unsafe lifting situations and sequence lifting steps in the correct order.**

**Lifting Heavy or Cumbersome Loads.** When you must lift a heavy or bulky object from the floor, remember this advice: USE YOUR LEGS—NOT YOUR BACK. If you are not mindful of this advice, you can hurt your back. A hurt back is often difficult to heal and can keep you from taking part in many athletic activities. Figure 2-6, safe lifting procedures, illustrates the way you should lift. Study the figure and pay particular attention to the feet, legs, and back. Lifting and setting down are the first and last movements performed in handling materials. When done by hand, it is during these movements that most strains occur. It is important that a plumbing specialist consider the following basic lifting techniques so as to reduce the possibility of injury.

*a.* Consider the size, weight, and shape of the object to be carried. Do not lift more than you can handle comfortably. If necessary, get help.

*b.* Set feet solidly with one foot slightly ahead of the other for increased stability. Place the feet far enough apart to give good balance.

*c.* Get as close to the load as possible. Bend legs about 90° at the knees. Crouch, do not squat. It takes about twice as much effort to get up from a squat.

*d.* Keep the back as straight as possible. It need not be vertical, but it should not be arched. Bend at the hips, not the middle of the back.

*e.* Grip the object firmly. Maintain the grip while lifting and carrying.

*f.* Straighten the legs to lift the object and, at the same time, bring the back to a vertical position.

*g.* Never carry a load that you cannot see over or around. Make sure the path of travel is clear. Setting down an object requires just the reverse procedure.

**Exercises (034):**

1. Mark the following situation "S" (safe) or "U" (unsafe).

*S or U* *Situation*

____ a. Lifting scaffold boards 12 feet long with a helper.
____ *b.* Lifting an object 3 feet in diameter that weighs 45 pounds by yourself.
____ *c.* Lifting scaffold horse.
____ *d.* Lifting a sack of cement (94 pounds) by yourself.

2. Arrange the following steps for lifting a heavy load in the proper sequence. Place the letters in the blanks. ________, ________, ________, ________, ________

*a.* Keep your back straight.
*b.* Squat down.
*c.* Check weight and size.
*d.* Plant your feet well apart.
*e.* Lift slowly by pushing up with your legs.

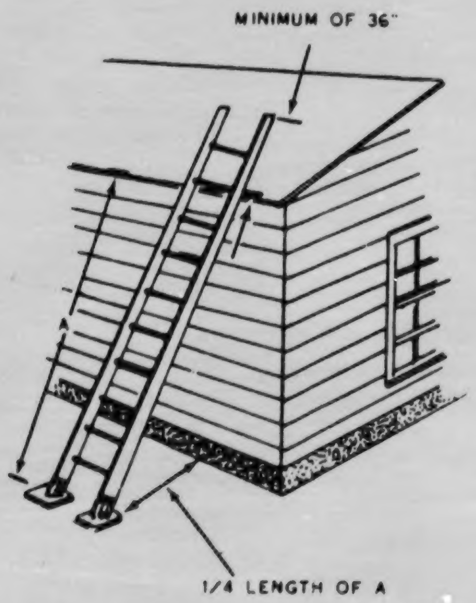


Figure 2-10. A properly placed ladder.

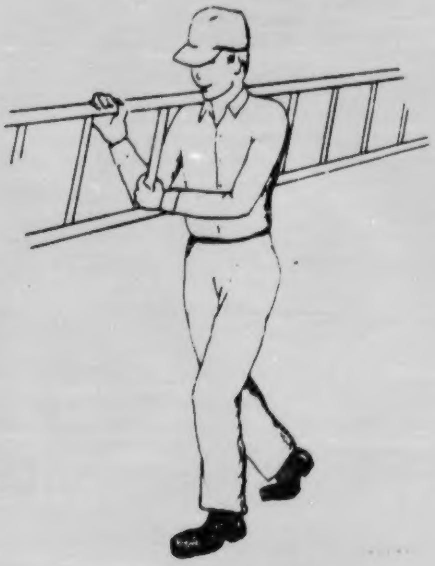


Figure 2-11. Carrying a ladder.

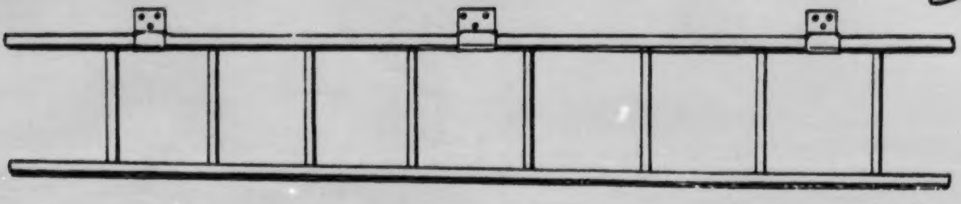


Figure 2-12. Storing a ladder.

## 2-7. Work Platform Safety

Many modern Air Force buildings are constructed with plumbing pipes, valves, and fittings above the ceiling. When you maintain this plumbing, you must work from ladders or scaffolds. Serious accidents have been caused by plumbers who use ladders or scaffolds improperly. A ladder or scaffold which is not erected properly not only endangers the worker using it but can cause harm to people who work near it.

**035. Given various uses of ladders, match the type of ladder with the type of use.**

**Selection of Ladders.** It is important for you to know the right type of ladder for the job. The most common types of ladders that you will be using are the single ladder, extension ladder, and stepladder.

*Single ladder.* The single ladder used by the plumber consists of two side rails from 8 to 26 feet in length, with rungs spaced 12 inches apart. A quality ladder will support up to 500 pounds. The size of a ladder is determined by its overall length. Figure 2-7, the single ladder, shows a typical single wooden ladder.

*Extension ladder.* The extension ladder, as shown in figure 2-8, consists of two or more sections. These sections overlap and can be extended by pulling the rope. They are available in lengths up to 60 feet. Extension ladders are required by the plumber to do work of short duration, such as inspect piping, open and close valves, and check vents on roofs.

*Stepladder.* A stepladder is a type of ladder that is self-supporting. Figure 2-9 shows a sturdy stepladder. This ladder can be used effectively as a portable work platform, because it has wide rungs to make it easier to stand on for long periods of time.

**Exercise (035):**

1. Match the type of ladder in column 2 with the uses stated in column 1.

| Column 1 - Uses | Column 2 - Ladders |
|---|---|
| ____ a. Used to get on a flat roof that is 30 feet high. | X. Single ladder. |
| ____ b. Used in the middle of a room. Plumber removes a panel from a 9-foot ceiling to close a valve. | Y. Stepladder. |
| ____ c. Used to get on a platform that is 15 feet high. | Z. Extension ladder. |
| ____ d. Used for a job requiring you to work for several hours. Your reach must extend 2 feet more than it can when you are standing at ground level. | |

**036. Using select situations, choose between those that demonstrate proper ladder raising techniques and placement and those that are improper.**

**Ladder Erection.** Erect a straight ladder by placing the base of the ladder (wide end) against the foundation of the structure. Raise the top and walk under the ladder toward the bottom end, grasping and raising the ladder rung by rung as you proceed. When

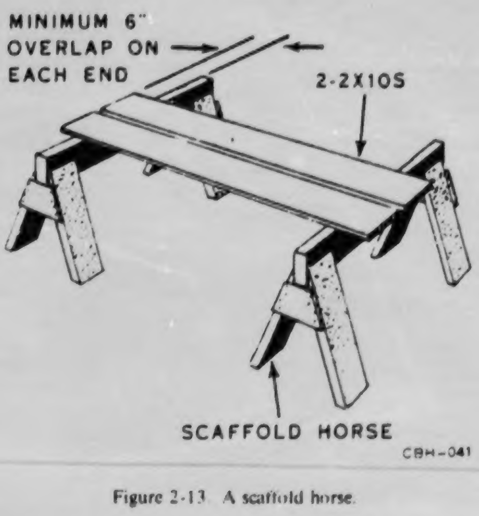


Figure 2-13. A scaffold horse.

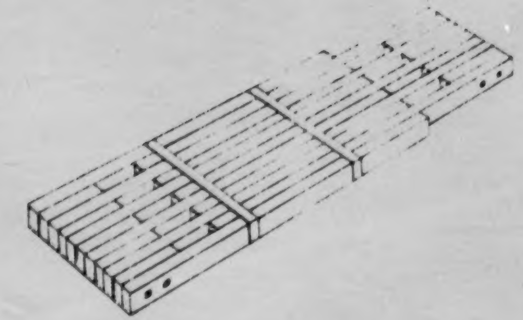


Figure 2-14. An extension plank.

the ladder is perpendicular, pull the bottom out from the building to a distance of one-fourth its length, as shown in figure 2-10, a properly spaced ladder. If you must get on top of the building, the ladder must extend at least 36 inches, above the eave, as shown in figure 2-10.

Erect extension ladders in the collapsed position in the same manner as the straight ladder. After the ladder is against the structure, extend the sections by the means provided until the ladder reaches the necessary height.

To erect a stepladder, spread the back legs away from the front legs until the locking device locks. This locking device keeps the legs from collapsing when weight is placed on the ladder.

**Exercises (036):**

1. Distinguish between the situations that demonstrate the proper ladder raising techniques and improper techniques by placing a Yes or No in the blanks provided.

____ *a.* The top of a 20-foot ladder extends 4 feet above the roof. The base of the ladder is 4 feet from the foundation.

____ *b.* The top of a 10-foot ladder extends 36 inches above the eave.

____ *c.* Extend an extension ladder on the ground before raising it.

____ *d.* Spread a stepladder until the legs lock in position.

____ *e.* Place the bottom of a straight ladder against a foundation to raise it.

2. What part of the straight ladder do you grasp with your hands when you erect it?

**037. In various situations concerning the use of ladders, match the situation with the appropriate ladder safety precaution.**

**Ladder Safety.** Observe these safety precautions when using ladders:

*a.* Always inspect a ladder before using it.

*b.* Before climbing a ladder, be sure that both rails rest on solid footing.

*c.* Equip the ladder side rails with safety shoes, as shown in figure 2-7. This is especially necessary when

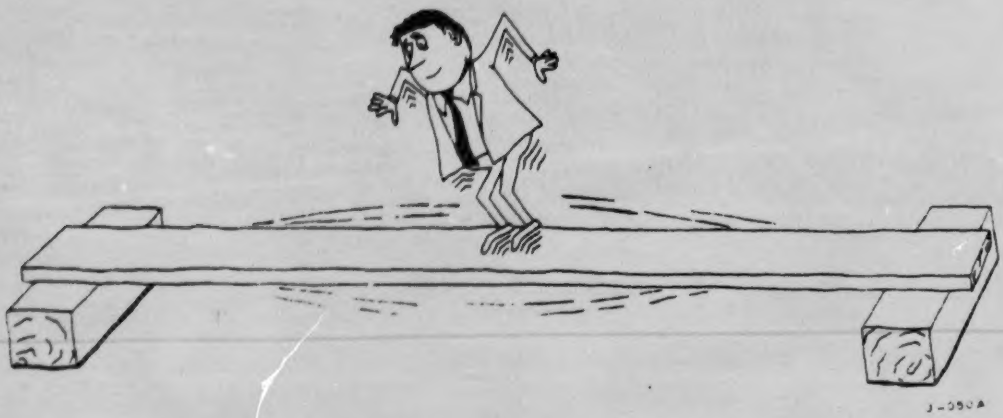


Figure 2-15. Testing a scaffold board.

you use the ladder on surfaces that would permit the ladder to slip.

*d.* Under no circumstances use stepladders as substitutes for workbenches.

*e.* When ascending or descending a ladder, face the ladder and hold on to each side rail.

*f.* When the security of a ladder is endangered by other activities, rope off the area around it, fasten it securely, and assign a man to steady the bottom.

*g.* When you use a ladder in front of a door, lock the door or block off the door and route personnel to another exit.

*h.* Never leave a ladder unattended for any length of time while it is erected—take it down and lay it on the ground.

*i.* When working from a ladder, stand no higher than the third rung from the top and do not attempt to reach beyond a normal arm's length.

*j.* If you need help to do the work, have your helper get another ladder—don't allow anyone on the ladder with you.

*k.* Never climb a ladder while using both hands to hold material; at least one hand must be used while climbing or descending a ladder.

*l.* Never place either the top or the bottom of a ladder against unstable material.

*m.* Before climbing a stepladder, be sure it is fully open and locked and that all four legs are on solid footing.

*n.* Do not leave tools on the top of a stepladder unless it is equipped with a special holder.

*o.* Do not stand on either of the top two steps of a stepladder.

*p.* Never use metal ladders where there is a possibility of coming in contact with electric current.

*q.* Get help when erecting long, heavy ladders.

**Exercise (037):**

1. Match the following situations with the safety precaution by placing the letter in the blank provided:

| Safety Precaution | Situation |
|---|---|
| ___1. Safety shoes. | a. Climbing a ladder. |
| ___2. Do not stand on two top steps. | b. Working from an extension ladder. |
| ___3. Rope off the area. | c. Before climbing a stepladder. |
| ___4. Do not use near electrical apparatus. | d. Using step ladder. |
| ___5. Stand no higher than third rung from top. | e. Be sure ladder rails are equipped with these before climbing. |
| ___6. Face the ladder and use both side rails. | f. Using metal ladder. |
| ___7. Be sure locking device is locked. | g. Ladder placed in area of other activities. |

**038. Given statements concerning the care of ladders, distinguish between the ones depicting proper care and those depicting improper care.**

**Care of Ladders.** Inspect ladders for defects and discard a ladder if any defect has developed. When it is necessary for you to carry a ladder, carry it over your shoulder with the front end elevated, as shown in figure 2-11. Do not drop it or allow it to fall, as the impact will weaken it. Store the ladder horizontally on three hangers, as shown in figure 2-12, to prevent sagging. Do not store near heat or expose to the weather elements.

**Exercises (038):**

1. Mark the following situation C or I in the blank provided to denote which are correct and which are incorrect.

____ a. Carry a ladder with the front end elevated.
____ b. Use two hangers to support a ladder when storing.
____ c. Store a ladder near a stove.
____ d. Let the back end of a long ladder drag.
____ e. Inspect a ladder for defects before using it.
____ f. Store a ladder leaning against a wall.

2. Complete the following sentence: A ladder with a broken rung must be __________.

**039. Given statements pertaining to scaffold erection and use, select those that are safe and those that are unsafe.**

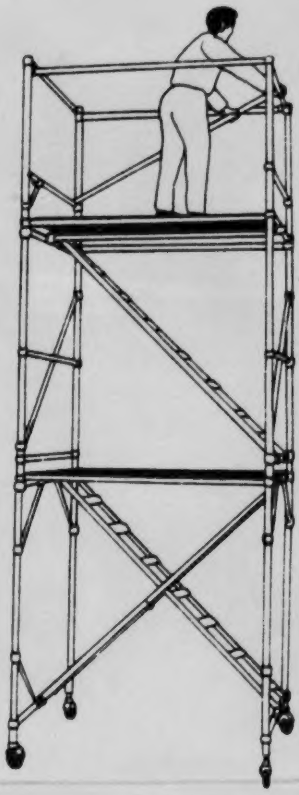
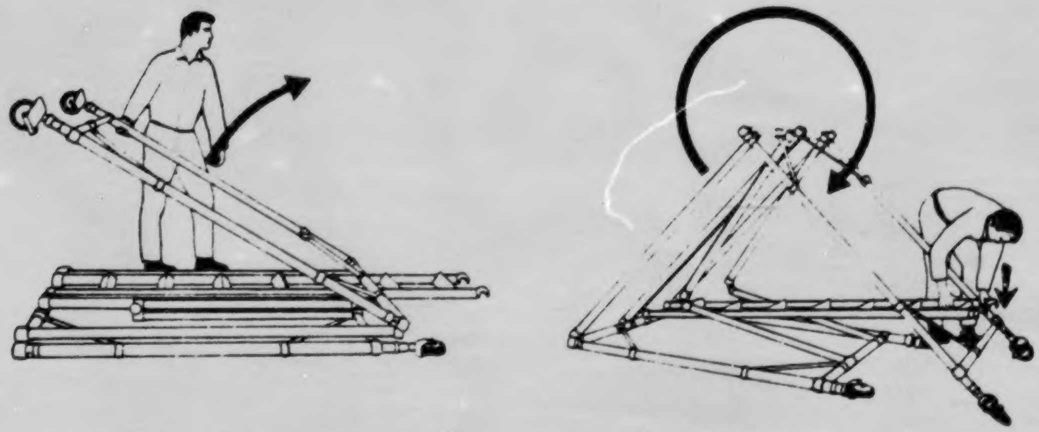


Figure 2-16. Aluminum stairway scaffold.

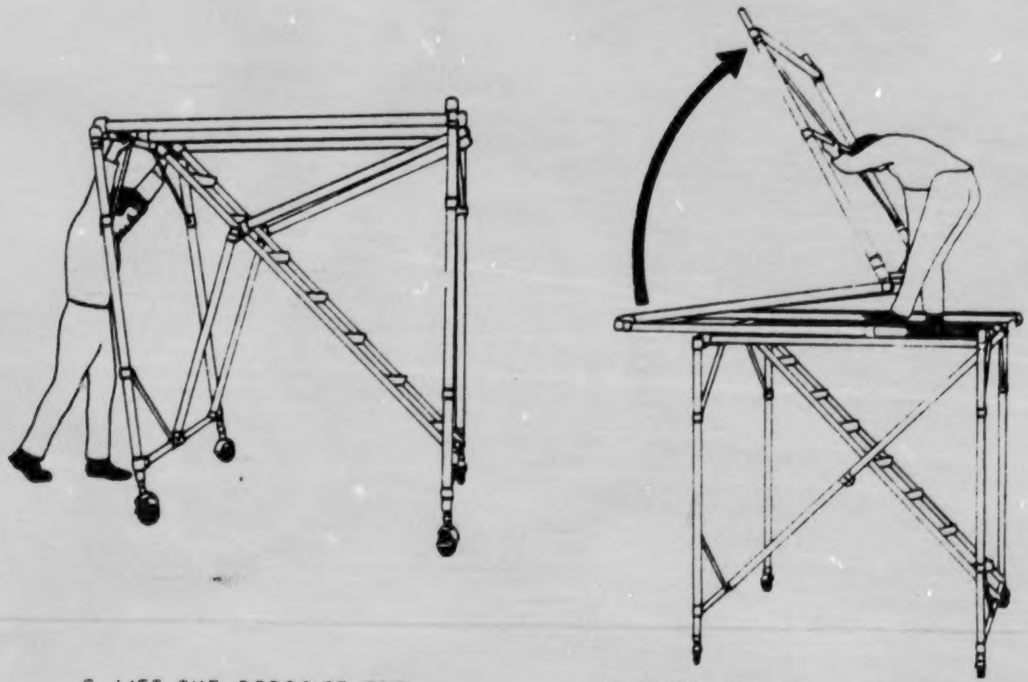
**Erection of Scaffolds.** The plumber is required to do some of his work from elevated platforms. There are many types of scaffolds available for you. The two most common which you are apt to use are the scaffold horse and the aluminum stairway scaffold.

*Scaffold horse.* A pair of scaffold horses with scaffold boards placed across them make a very useful scaffold. It is erected quickly and can be easily moved as the work progresses. The use of this type of scaffold is limited to the height of the scaffold horse.



A. SWING THE END FRAME 270°

B. SNAP THE LOWER CROSSBAR INTO THE STAIRWAY HOOKS



C. LIFT THE OPPOSITE END

D. RAISE THE TOP END FRAME

Figure 2-17. Erecting aluminum stairway scaffold.

Figure 2-13 shows a pair of scaffold horses with two scaffold boards. Always use at least two boards to form a platform on any scaffold. These boards should be 2 x 10 or larger. Instead of using the boards, you may use an extension plank, as shown in figure 2-14. The extension plank is very strong. You can change its length by sliding the two movable parts in and out. If you use the extension plank on scaffold horses, it should overlap the horses at least 6 inches.

*Scaffold horse safety.* The following safety precautions are presented for your use. Think about them so that you make safety a part of your work habits.

- Inspect the scaffold horses for split members, loose knots, and bad nailing.
- Set the scaffold horses on firm, even footing for each leg.
- Test scaffold boards before using by jumping on them, as shown in figure 2-15.
- Never use a scaffold board that is not a minimum size of 1 ½ x 9 ½ inches (2" x 10").
- Place the boards close together on the horses.
- Do not overload the scaffold.
- Do not step on the end of a plank as your weight may overbalance the plank.

**Aluminum Stairway Scaffold.** This type of scaffolding can be set up by one person. It is easy to set up and, when erected properly, is very safe. Figure 2-16 shows an aluminum stairway scaffold that is ready to use. It is two sections high. If you erect the scaffold three or more sections high, you must first install outrigger supports to the first section. Figure 2-17 shows four views of how to erect an aluminum stairway scaffold. In view "A" you start the first section on the floor with the stairway threads facing up. View "B" is the second step of the sequence. You hook the lower part of the stairway to the lower crossbar. In view "C" you straighten up the scaffold. Note the braces in the middle of the diagram. They should snap into a locked position. Check to make sure that the latches on the braces are locked. Level the legs before climbing the ladder and lock all caster brakes. View "D" shows how you erect the second section. Before you try putting up a scaffold of this type, read the manufacturer's instructions and ask your supervisor to show you how to do it.

**Stairway Scaffold Safety.** Safety rules that apply to stairway scaffolds follows:

- Apply all caster brakes before climbing the scaffold.
- Never move a scaffold when a person or material is on it.
- Scaffold must be level at all times. Never make leg adjustment when anyone is on the scaffold.
- Don't try to "stretch" the platform height with the adjusting lets. If you need additional height, add another section.
- Do not lean a ladder against a scaffold or place a ladder on the platform of a scaffold.
- Never push, pull, or lean against a wall or ceiling when standing or sitting on a scaffold, unless it is securely tied to the building.
- Make sure all locking devices are in the safety position.
- Always install a safety railing when a platform is to be used at heights of 4 feet or over.
- Never use any scaffold in the vicinity of live electrical apparatus or near machinery in operation.
- Do not work from scaffold stairways.
- Stairways are designed to support a 200-pound person. Do not overload.
- Always use the stairway for access to the platform, not the structural members.
- Do not exceed a maximum distributed load of 750 pounds on the platform.

**Exercises (039):**

Mark the following statements with an "S" if they are safe or with a "U" if they are unsafe.

____ 1. Use a scaffold horse with only one defective leg.
____ 2. Cross braces with the locking devices locked.
____ 3. Climbing scaffold cross braces to reach the platform.
____ 4. Using three 2 x 8 scaffold boards.
____ 5. Ladder on scaffold to reach higher.
____ 6. Scaffold boards extend 8 inches beyond scaffold horse.

CHAPTER 3

# Job Tools and Equipment

TOOLS AND equipment play a very important part in the everyday work of a plumber. As a plumbing specialist, you are helpless without them. In this chapter, you will cover the common handtools that you use in your trade and those that you usually carry in your toolbox. You will also cover the care and maintenance of special tools, shop tools, and equipment that you use in the plumbing shop.

## 3-1. Plumbing Tools

The efficiency of a plumber is determined to a great extent by his tools and the attention that he gives to their care. You can tell an expert from a shade-tree mechanic by the manner in which he handles his tools and the way he cares for them. The shade-tree mechanic leaves his tools where he uses them. They are dirty and greasy, and he spends a lot of time just looking for the proper tool. He hardly ever cleans the area in which he works. Everything about his area of work looks like a mess. On the other hand, the skilled specialist has a place for every tool and he keeps the tool in its place until it is ready for use. He cleans his tools before putting them up, and he keeps them sharp and ready for work. Also, he keeps the area in which he works clean and orderly. The tools you use are classed in three groups: common handtools, shop tools, and special tools.

**040. Given situations and a list of plumbing handtools, match the appropriate tools with each situation.**

**Common Handtools.** Common handtools, such as hammers, pliers, screwdrivers, saws, drills, and wrenches, are usually considered personal tools because you keep them in your toolbox. You should lock your toolbox when you are not using it, because you are responsible for those tools.

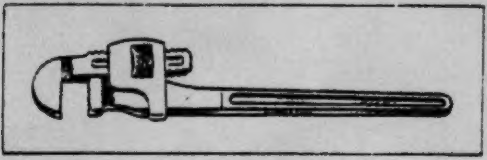


Figure 3-1. Pipe wrench.

Some of the more important of these handtools are described in this section.

*Pipe wrench.* The pipe wrench, shown in figure 3-1, is probably the most common wrench you will use. Use it for turning or backing up pipe and fittings during assembly when the pipe and fittings offer no gripping surface for other types of wrenches. Standard pipe wrenches can be obtained in sizes from 6 inches to 60 inches. The number stamped or cast on the handle indicates the size of the wrench. Do not use a pipe wrench on chrome pipe fittings where there is danger of damage to the surface from the bite of the wrench jaws. Never exert a hard pull on a wrench until it has a firm grip on the pipe. You should adjust the jaws of the wrench to take a full grip on a pipe; but don't allow the pipe to slip below the grip in the jaw opening, because the wrench may "kick off" and injure you.

When you use a pipe wrench, be sure that the teeth on the jaws are clean and sharp. When the teeth become dull, sharpen them with a grinder or a file, depending upon their hardness. When the teeth become worn, replace them by inserting a new hook jaw and heel jaw. Always select the proper pipe wrench for the particular job. A shim should be used to make an improper-sized wrench fit. A pipe wrench should never be used as a substitute for any other wrench. When using a wrench, place it on the pipe in such a position that a pull on the handle will tend to force the jaws farther onto the pipe; always pull the handle rather than push it. Never use a wrench in place of a hammer; this practice weakens the wrench and is generally unsafe. A pipe or other device should not be used to extend the wrench handle for greater leverage. Do not hammer on a wrench handle, because it will roughen the handle which will then likely cut your hand. Defective wrenches, such as those with spread or distorted jaws, crooked handles, cracks, and other defects, should not be used.

*Pipe taps.* Assume that you want to tap a 2-inch water line to install a 1/4-inch pipe for an evaporative cooler. You can drill a 7/16-inch-diameter hole in the pipe, ream the hole, then cut threads with a tap. Pipe taps for cutting internal threads are available in a wide range of sizes, as shown in figure 3-2. Note too, that the figure shows the proper-size drill for boring the hole, as well as the number of threads per inch.

| NATIONAL PIPE THREADS | | |
|---|---|---|
| SIZE OF TAP | THREADS PER INCH | TAP DRILL |
| 1/8 | 27 | R |
| 1/4 | 18 | 7/16 |
| 3/8 | 18 | 37/64 |
| 1/2 | 14 | 23/32 |
| 3/4 | 14 | 59/64 |
| 1 | 11-1/2 | 1-5/32 |
| 1-1/4 | 11-1/2 | 1-1/2 |
| 1-1/2 | 11-1/2 | 1-47/64 |
| 2 | 11-1/2 | 2-7/32 |
| 2-1/2 | 8 | 2-1/2 |
| 3 | 8 | 3-1/4 |

Figure 3-2. Pipe taps for cutting internal threads.

*Adjustable jaw wrenches.* Adjustable jaw wrenches, like those shown in figure 3-3, have jaws that can be adjusted to fit square stock or the flat surfaces of a bolthead or nut. These wrenches should always be snugly adjusted to fit the work in order to prevent slippage and injury to the operator. An improperly fitted wrench not only rounds off the corners of a bolt or nut but also strains the jaws of the wrench. Adjustable jaw wrenches should be used as shown in figure 3-4. Undue strain on the wrenches is likely to crack the movable jaws or damage the adjusting screw. Keep the wrench clean and the movable parts oiled.

*Slip-joint pliers.* Combination slip-joint pliers, illustrated in figure 3-5, are used to hold round stock and hot metal. They are also used to cut and bend wire. Pliers should never be used to hold chromium, brass, or copper pipe and fittings, since they are likely to scratch the surfaces. Neither should pliers be used on nuts or bolt heads, because pliers round the corners on nuts or boltheads so that a conventional wrench cannot get a firm grip. Never use pliers as a pry bar, because you will probably bend and break the handles. Keep the pliers clean and well oiled at the pivot pins.

The teeth of the pliers should be kept sharp. If they become dull, they can be sharpened with a bench grinder, as shown in figure 3-6. Always keep the pivot pin tight. Some pivot pins have a nut that can be tightened, while others have a solid pin that must be peened to tighten the jaws.

*Water pump pliers.* The water pump pliers, shown in figure 3-7, have a larger jaw opening and longer handles than the regular slip-joint pliers. They are used on larger materials where a greater grip is required. The precautions and maintenance procedures for these pliers are similar to those for slip-joint pliers.

*Shears.* Shears, or tin snips as they are sometimes called, are illustrated in figure 3-8, they are useful in cutting lightweight sheet metal, gasket stock, and other materials that are easily cut by shearing action. They should never be used to cut wire or rod stock, because this use will probably damage the cutting edge of the blade. Ordinary shears are usually issued in 6- and 12-inch sizes. The most commonly used shears are the straight blade type. The curved blade type is used to cut circular shapes. Shears are usually sharpened with a power bench grinder. Keep the shears clean and the pivot pins well oiled.

*Brace.* The plumber frequently will be required to

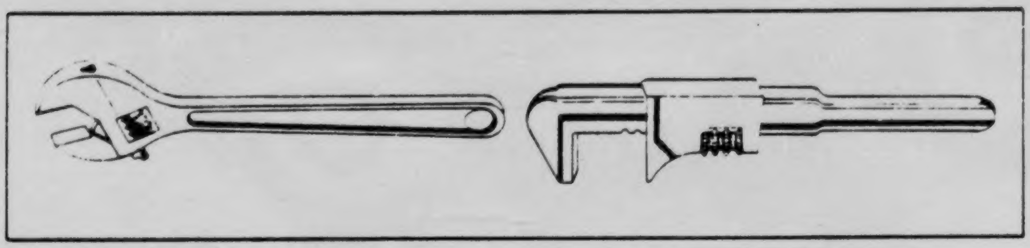


Figure 3-3. Adjustable jaw wrenchs.

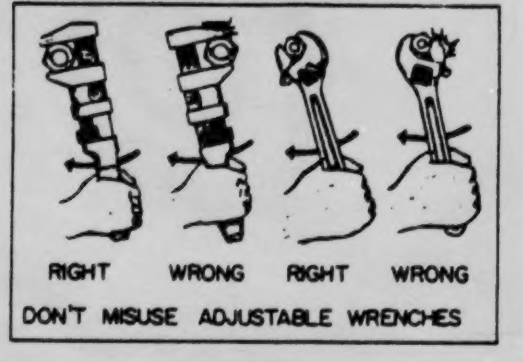


Figure 3-4. Correct and incorrect ways to use an adjustable jaw wrench.

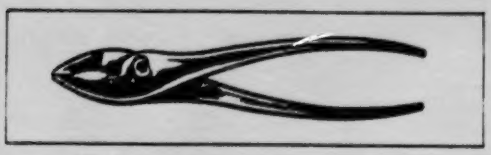


Figure 3-5. Slip-joint pliers.

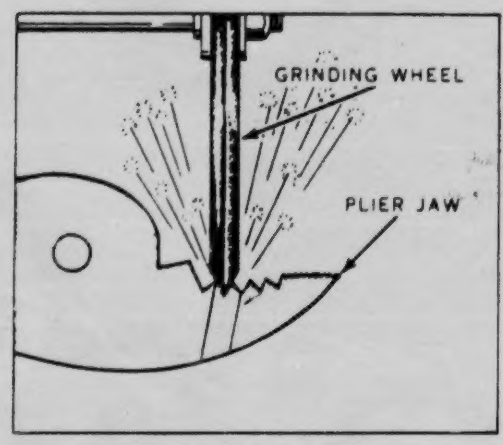


Figure 3-6. Sharpening plier teeth.

bore holes in wood during plumbing installation procedures. This is a simple operation which involves the use of a brace and an auger bit. The brace, shown in figure 3-9, consists of a knob, crank, and chuck for holding the bit. The chuck usually has a ratchet arrangement that allows the handle to turn in either direction while turning the chuck. This permits the boring of holes in places where a full revolution of the crank cannot be made. The chuck is designed to hold only auger bits that have a square tang. The brace should not be handled roughly, because the wooden parts are apt to break. Keep the brace clean and the moving parts well oiled.

*Auger bits.* Auger bits are the tools that are placed in the chuck of a brace to do the drilling. They are available in sizes from 1/4 inch to 1 inch. The point of the bit is designed with a spur, nibs, and lips. The nibs score the circle and cut the fibers as the bit is turned. The lips act as small chisels which shave the wood and scoop the shavings into the twist. The spur feeds or pulls the bit into the wood. Often the nibs and lips become dull. These may be sharpened with a special auger bit file. To sharpen the nibs, hold the auger bit against a solid surface, as shown in figure 3-10, and lightly file the cutting edges on the nibs on the inside only. Do not file off any more material from the nibs than is necessary to get them sharp. Stop filing when a fine bur appears on the cutting edge. Remove the spur from the nibs with a light touch of the file.

In sharpening the lips of the bit, hold it against a solid surface with the spur pointing downward, as shown in figure 3-11. File each lip lightly on the top side only. Use care to keep the original chisel-like shape of the lip edge. Stop filing when a fine bur appears on the lip edge. Remove the bur with a light touch of the file. If the spur of the bit becomes damaged, it is difficult to repair; and, usually, you will have to turn the bit in to supply for a new one.

*Expansion bit.* An expansion bit, shown in figure 3-12, is also used with the brace. It is an adjustable boring tool with a movable blade that can be adjusted to cut holes from 7/8 to 3 inches in diameter. The expansion bit is sharpened in the same way as the regular auger bits.

*Hammers.* There are two general types of hammers used by the plumber: the claw hammer and the

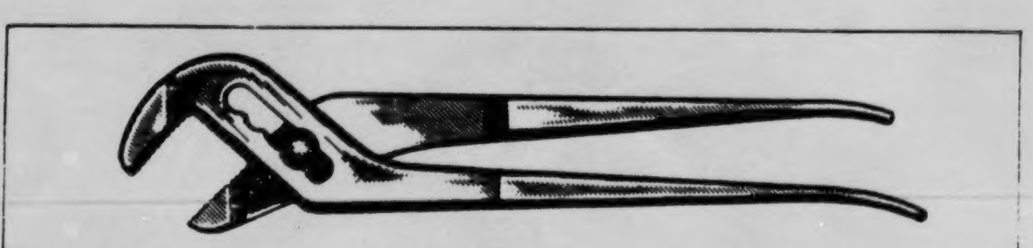


Figure 3-7. Water pump pliers.

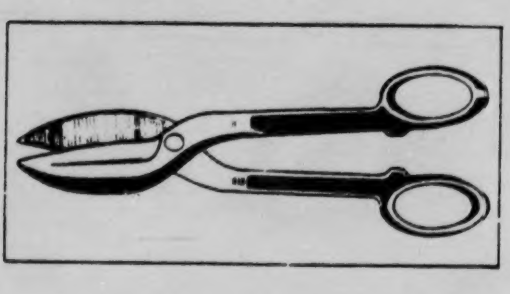


Figure 3-8. Cutting shears.

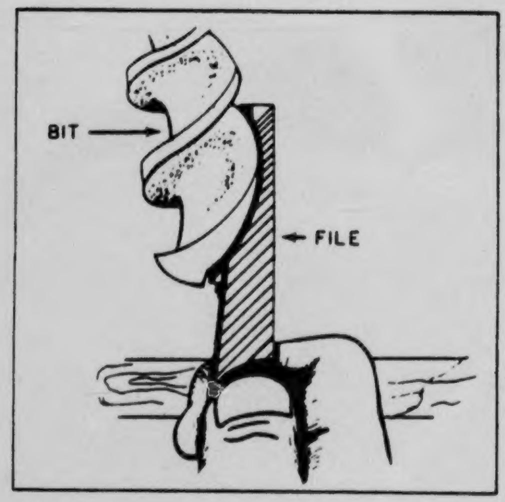


Figure 3-11. Sharpening the lips of an auger bit.

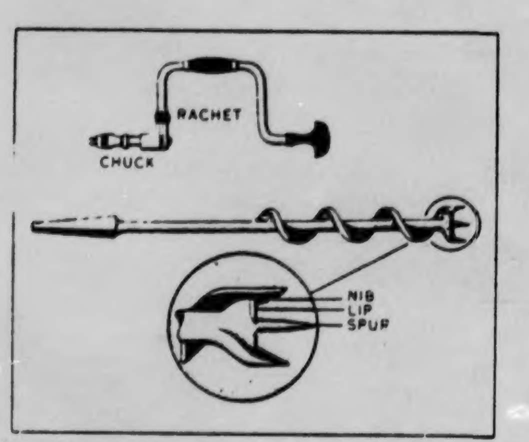

RACHET
CHUCK
NIB
LIP
SPUR

Figure 3-9. Brace and bit.

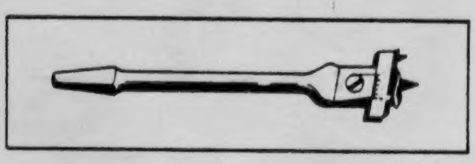


Figure 3-12. Expansion bit.

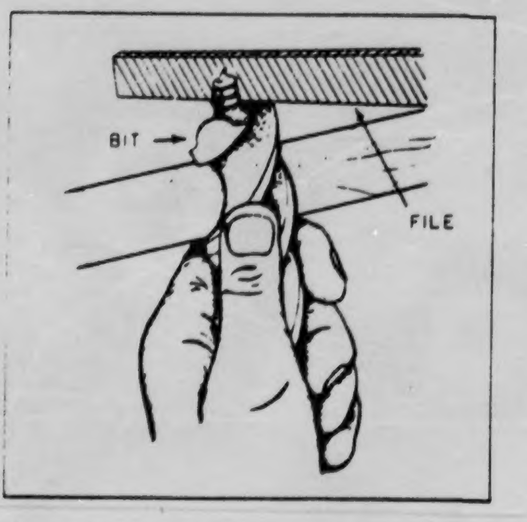


Figure 3-10. Sharpening the nibs of an auger bit.

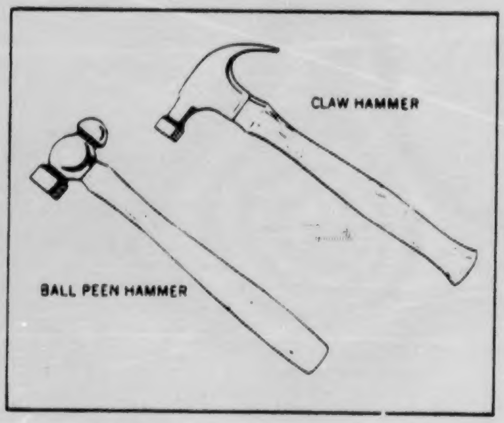

CLAW HAMMER
BALL PEEN HAMMER

Figure 3-13. Hammers used by plumbers.

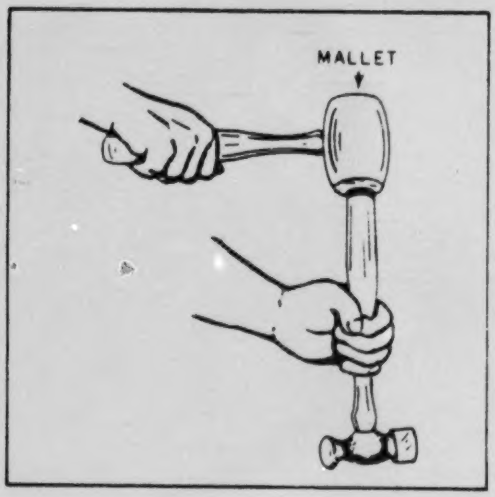


Figure 3-14. Seating a handle in a hammer head.

machinist ball peen hammer, illustrated in figure 3-13. The claw hammer is used to drive and pull nails, and the ball peen hammer is used to drive calking irons, chisels, and punches. When you use a hammer, be sure the head is secured to the handle. If the handle is loose, install new wedges. If the handle is worn or cracked or if it cannot be tightened, you may have to replace it with a new one.

To remove the old handle from the head if it is tight, saw off the old handle next to the hammer head, drill a hole in the portion of the handle left in the head, and drive it out with a punch. Next, you are ready to shape the new handle to fit the head. You may shape it with a rasp or spokeshave. Insert the new handle into the head occasionally during the shaping process to determine if it fits. After the handle is shaped, firmly seat the head on the handle by striking the end of the handle with a mallet, as shown in figure 3-14. Saw off the projecting portion of the handle close to the hammer head with a hacksaw. Drive new wedges into the handle. As a final operation to make a smooth job, grind or file the end of the handle even with the hammer head.

Sometimes the face of the hammer is uneven because of wear and damage. It can be reconditioned with a bench grinder. First, inspect the face to determine if it is to be plain or bell shaped. Then, grind it to its original shape. Keep the hammer cool by frequently immersing it in water.

Spirit level and plumb bob. The level, one type of which is shown in figure 3-15, is used to determine either the horizontal or vertical trueness of your work. The frame of the level is made of either wood or aluminum. In the frame are glass tubes which contain air bubbles and a liquid. The tubes for horizontal and vertical leveling are marked to indicate their center and are aligend with the edge of the frame so that the bubble will be centered in the tube whenever the frame is level. The level is used for settiing batterboards, digging ditches, and installing fixtures. The glass tubes are easily broken, so do not handle the level carelessly. Keep the level clean and well protected in your toolbox.

The plumb bob, also shown in figure 3-15, is a pointed device which weighs approximately 9 ounces. It is made with holes at the top by which it can be hung on a cord. The plumb bob is used to establish the location for openings in the ceiling and floor. Keep the cord wrapped neatly around the bob when it is not in use. Oil the plumb bob with a light coat of oil to prevent rust.

Rules. The folding rule, shown in figure 3-16, is used by most plumbers when laying out and measuring a plumbing job. The rule is constructed of sections which are hinged together so that they can be folded into a compact unit and carried in the pocket. The folding rule must be unfolded carefully to prevent the breaking of the sections near the joints. If the joints become hard to operate, place a few drops of oil on

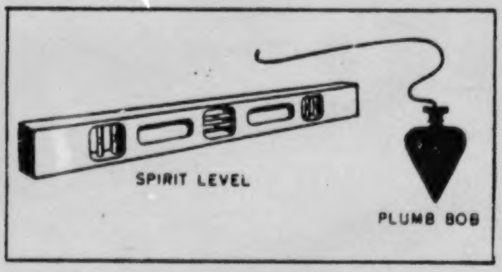


Figure 3-15. Spirit level and plumb bob.

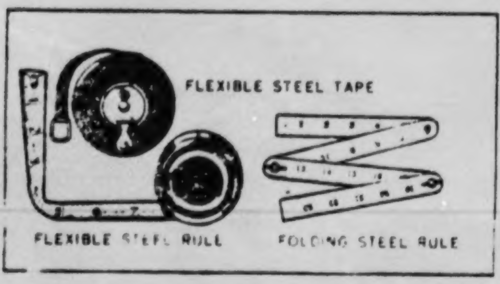


Figure 3-16. Rules and tapes

each joint. Keep the rule clean and numbers well protected.

Flexible steel rules and tapes, also shown in figure 3-16, may be used in place of the folding rules. When you are taking larger measurements, a 50-foot or a 100-foot flexible steel tape is desirable. Flexible rules and tapes must be kept clean and dry. If dirt or sand gets in them, it tends to wear away the numbers, and moisture causes the surface of the steel to rust. When you use a flexible steel rule or tape, be careful not to kink it. Usually, it will break at the kink. Use a very light oil on these measuring devices to keep them from rusting.

*Files.* Files are used for cutting, smoothing, and removing small amounts of metal. Some of the different types are illustrated in figure 3-17. When filing, hold the file handle with your right hand and hold the end of the file between your thumb and first finger of your left hand. Use long, steady, and uniform strokes. Heavy pressure on the file is apt to clog the file or strip the teeth.

The cutting action of a file produces small particles or chips called filings. These filings frequently wedge between the teeth of the file and impair the efficiency of the file. For this reason, frequent cleaning is necessary. A file may be cleaned with a special steel brush called a card file. Move it across the file parallel with teeth. When filing a tool, be sure that the file is sharp and that the tool is held securely in a vise. File away from the cutting edge. This will prevent injury to your hand in case the file slips.

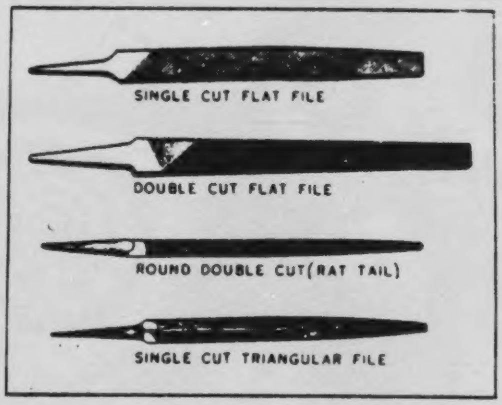


Figure 3-17. Various types of files.

Never use a file as a pry bar or hammer. The tang is soft and bends easily. The body is hard and very brittle, and even a slight bend or blow may cause a file to snap or shatter. Do not strike the file against a vise or similar object to clean it, because this will probably ruin the file teeth or break the file. Never use a file without a file handle.

*Screwdrivers.* Screwdrivers are tools for driving or removing screws. Figure 3-18 shows several types of screwdrivers. The two common types used by the plumber are the standard and the cross-point (Phillips). The standard screwdriver blade must have sharp corners and fit the slot in the screw closely. It should be held firmly against the screw to prevent it

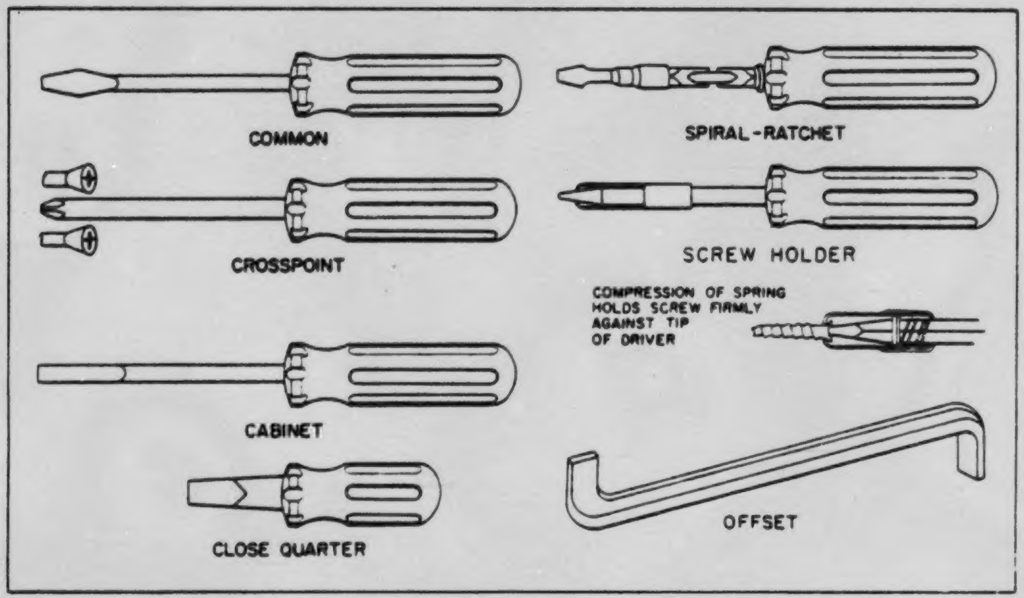


Figure 3-18. Various types of screwdrivers.

from slipping and injuring the worker or marring the work. Do not hold the object you are working on in your hand when you are tightening or loosening a screw. If the blade should slip, it may injure your hand. Do not use a screwdriver as a chisel or pry bar, because such abuse could crack the handle or bend the blade. If you use a screwdriver that is too small, you will probably ruin the channel in the head of the screw. You may also bend or break the screwdriver blade. Never use pliers or a wrench to increase the leverage on a screwdriver, because abusing the screwdriver in this manner is likely to bend the blade or break the point. Apply only the amount of pressure that can be exerted on the handle with the hand.

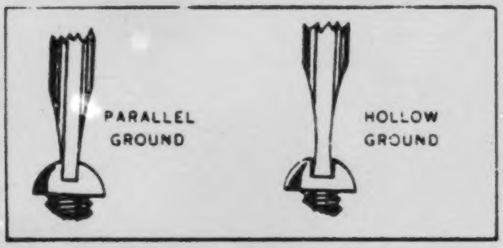


Figure 3-19. Shapes of screwdriver bits.

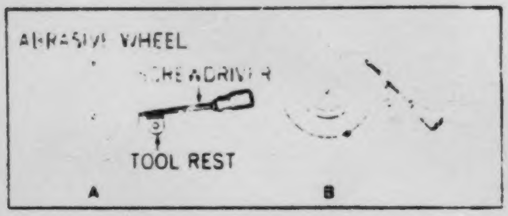


Figure 3-20. Sharpening a screwdriver bit.

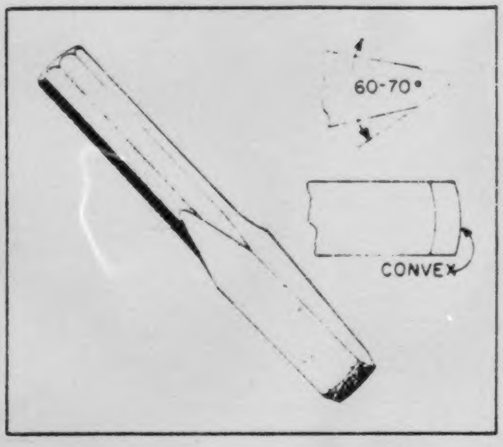


Figure 3-21. Cold chisel.

The bit tip or blade of the screwdriver is extremely hard. This is necessary for it to hold its shape and resist the shearing action of the screw slot. The shank of the bit is softer and tougher than the hard brittle tip, because it has to resist the twisting strain. When the tip becomes rounded or broken, you can usually restore it to its original shape with a bench grinder.

Screwdriver tips should be grounded so that the sides are parallel to keep them from slipping out of the screw slot. It is also good practice to slightly hollow the sides of the blade, as shown in figure 3-19. This puts the tip of the blade at the bottom of the screw slot making it easier to drive and remove screws without damaging the screw head.

To remove the nicks and to square the tips of the screwdriver correctly, adjust the bench grinder rest to hold the screwdriver at right angles to the grinding surface of the abrasive wheel, as shown in A of figure 3-20, and grind the ends square. Next, adjust the rest to hold the screwdriver against the wheel to give the desired parallel or concave shape, as shown in B of figure 3-20, and grind both sides until the tip is the correct shape and thickness. Periodically, during the grinding procedure, dip the tip of the screwdriver in water to keep it cool so that it will retain its hardness.

*Cold chisel.* Cold chisels are tools used to cut or chip metal. The flat chisel, like the one shown in figure 3-21, is used by the plumber to cut cast-iron soil pipe and sheet metal. Keep the cutting edge sharp and ground to the original angle. The cutting angle is determined according to the hardness and softness of the metal to be cut. A cutting edge angle of 70° is fine for most light metals; however, an angle of 90° is recommended for hard and tough metal.

Always wear goggles when using a chisel. Keep the hammer and chisel clean and free of grease and oil to prevent the hammer from slipping and bruising your hand. When the cutting edge of a chisel becomes dull, sharpen it with a bench grinder. To grind a chisel, set the rest on the grinder to secure the desired bevel angle. Move the chisel head from side to side a little during the grinding operation to slightly curve the cutting edge. Turn the chisel over and grind the other bevel. Keep the bevels the same angle, or the cutting edge will not be centered. Dip the chisel in water frequently to preserve the temper.

Do not use a chisel with a mushroomed head, as shown in figure 3-22, because there is danger of injury from flying pieces of metal when the chisel is struck with a hammer. Use a bench grinder to restore the head of the chisel to its original shape, as shown in figure 3-23.

*Punches.* A center punch, shown in figure 3-24, is used to mark the location of a hole that is to be drilled. When the drill is placed in the center punchmark, it starts drilling the hole at that particular point. If the hole is drilled without first locating it with a center punchmark, the drill will usually tend to move about on the piece of metal. This is called wandering; and when the drill starts to wander, the operator has no control over the exact location of the hole. A center punch point is usually ground to a cone shape of 90°, as shown in figure 3-24. Sometimes the point of a center punch becomes worn, and it must be reground. This is done with a bench grinder. To grind the center punch point to the proper angle, adjust the grinder rest so that the punch meets the wheel at the proper angle. Place the punch point on the rest and against the wheel. Rotate the punch during the grinding process to make the point symmetrical. Dip the punch in water at frequent intervals to keep it cool. Heating the punch point excessively will draw the temper out of it. Do not grind away more material than is necessary to secure a satisfactory point.

Never use a punch with a mushroomed head, because it will probably cause a hand injury if it slips through the fingers or a facial injury from flying pieces of metal broken from the mushroomed portion of the punch. Grind off the mushroomed portion of the punch with a bench grinder.

*Saws.* The hacksaw, one type of which is shown in figure 3-25, is used for cutting metal. Most hacksaws have adjustable frames which use blades from 8 to 16 inches in length. A variety of hacksaw blades are available. They differ in the hardness of the blade and the number of teeth per inch. A hard blade is best for sawing brass, tool steel, or cast iron; but a flexible blade is better for cutting hollow shapes and metals of light cross section, such as tubing, tin, or copper. Always keep the saw in line with the cut being made, and do not bear down on the back stroke because you may cramp and break the blade. The blade may break if you push down too hard on the cut or fail to push the saw in a straight line. If the blade breaks, it can cut your hand. Do not push down on a hacksaw to try to make it cut faster. The weight of the saw should be sufficient to cause the blade to bite into the metal. Keep the hacksaw clean and stored where the blade is protected from becoming dull or broken. Dull hacksaw blades cannot be sharpened; they must be replaced.

The keyhole saw, shown in figure 3-26, has a narrow, pointed blade; it is used to cut holes in wood partitions or to make a circular hole to fit a pipe. First, make a pilot hole with a brace and bit. Then, insert the pointed end of the blade into the hole and saw with short strokes. Do not run the saw into nails when you are sawing a hole in a structure, and do not force the saw because the narrow blade is apt to buckle or break and thus cause an injury. A dull saw is more dangerous than a sharp saw, because it binds or jams and is likely to break. A keyhole saw is sharpened with a single cut triangular file as is used for any other saw.

In addition to using the hacksaw and keyhole saw mentioned earlier, you will use two others: the ripsaw

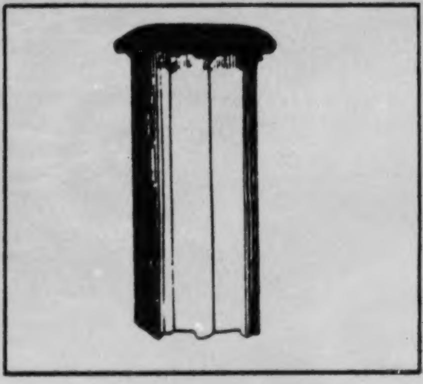


Figure 3-22. Mushroomed chisel head.

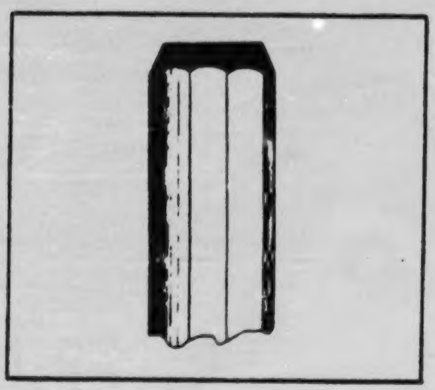


Figure 3-23. Mushroomed chisel head with the mushroomed portion removed.

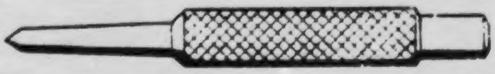


Figure 3-24. Center punch.

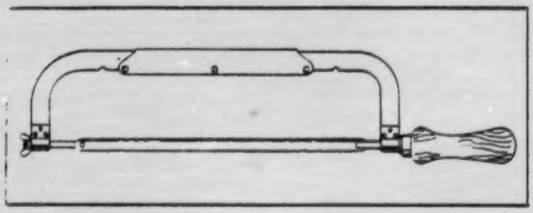


Figure 3-25. Adjustable hacksaw.

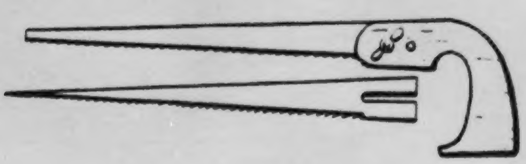


Figure 3-26. Keyhold saw.

and crosscut saw. A crosscut saw is illustrated in figure 3-27. A ripsaw is used to cut lumber parallel to the wood fibers, and the crosscut saw is used to cut at right angles to the fibers. Plumbers use saws for cutting openings in walls, partitions, and ceilings, and for the required construction on the job.

Saws are further identified by the length of their cutting edge and the number of teeth per inch. They are usually from 18 to 26 inches long. The number of teeth or points per inch determines the fineness or coarseness of the saw. The number of teeth is usually stamped on the heel of the saw blade.

A saw may be held in either of two ways. One way is to hold the saw with the four fingers looped through the handle. The preferred way, however, is to loop three fingers through the handle and extend the index finger along the side of the handle to serve as a guide. When a saw becomes dull, it can be sharpened with a three-cornered file. The saw is usually held on a special saw clamp during the filing operation.

*Knives.* The only knife that the plumber uses is the conventional folding, pocket type. Exercise care when using it. Be sure you push it away from the body when you are cutting with it. When the knife is not in use, fold and place it in the toolbox. Knives should not be used as a substitute for screwdrivers, nor should they be used as pry bars. All knife blades used for cutting must be kept sharp.

**Exercises (040):**

Fill in the blanks in column A, which contain situations related to common handtools, with one or more letters from Column B, which lists plumbing handtools.

*Column A - Situations*

1. Tighten a nut on a water closet. ________
2. Cut end off of a 2 x 6 board. ________
3. Mark wood wall and cut hole for 1" pipe. ____ ________
4. Establish mark for hole in wood floor directly under mark on ceiling and cut hole for 4" pipe. ______ ______ ______
5. Cut cast-iron pipe of specific length. ______ ______ ______
6. Make up two joints of 1½-inch pipe. ______
7. Cut 4½-inch square piece of lightweight sheetmetal and nail over 2-inch hole. ______ ______, ______
8. Shorten 1/2" bolt from 4" to 3¼". ______ ______
9. Sharpen auger bit. ______
10. Place pipe in vertical position. ______

*Column B - Handtools*

*a.* Pipe wrenches.
*b.* Adjustable jaw wrench.
*c.* Slip-joint pliers.
*d.* Water pump pliers.
*e.* Hacksaw.
*f.* Shears.
*g.* Brace and bit.
*h.* Brace and expansion bit
*i.* Keyhole saw.
*j.* Claw hammer.
*k.* Ball peen hammer.
*l.* Spirit level.
*m.* Plumb bob.
*n.* Rule.
*o.* File.
*p.* Screwdriver.
*q.* Cold chisel.
*r.* Ripsaw
*s.* Crosscut saw
*t.* Knife

**041. Given statements and a list of plumbing shop tools, match a tool with each statement.**

**Shop Tools.** We have covered some of the more important tools that the plumber carries to and from the job in his toolbox. Now let's take a look at some of the shop tools he uses on his job.

Shop tools are generally large tools that are used frequently but are too bulky and cumbersome to transport from one job to another in a toolbox. They are usually stored in a toolroom and must be checked out for use. Some of the more important shop tools are covered in this section.

*Pipe vises.* There are several types of vises that the plumber may use when cutting or threading pipe. Figure 3-28 illustrates a quick-release type that can be mounted either on a shop bench or on portable legs and carried to the job. Figure 3-29 shows a chain-type vise, which grips the pipe by a chain arrangement.

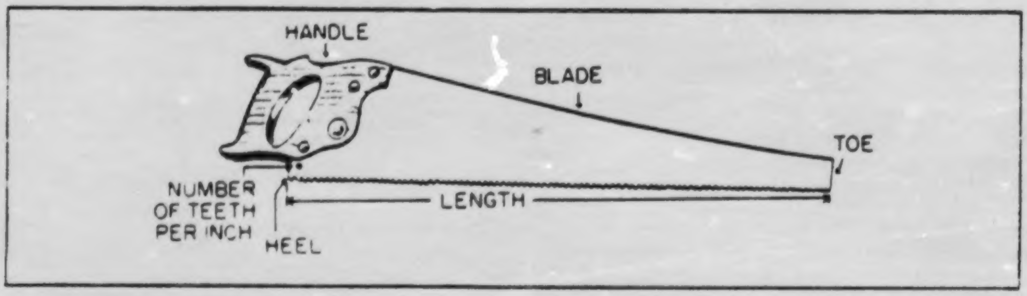


Figure 3-27 Crosscut saw.

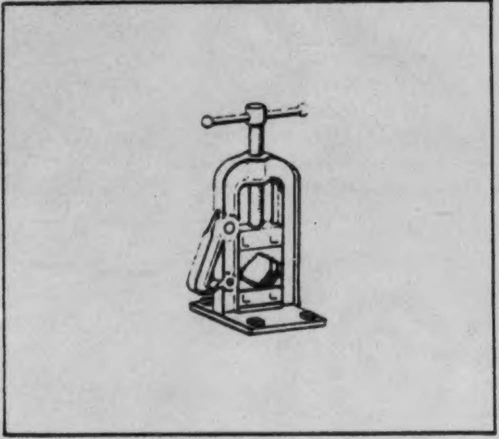


Figure 3-28. Quick-release pipe vise.

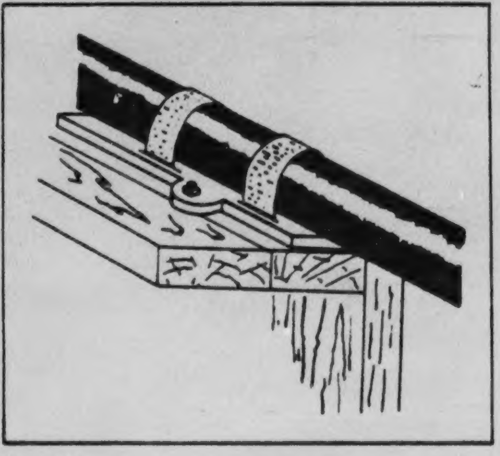


Figure 3-30. Strap vise.

Another type of vise is the strap vise, shown in figure 3-30. This vise is designed to hold the pipe with a strap arrangement. It is used to hold fiber, plastic, and asbestos pipe which might be damaged by vises with steel jaws.

Vises require very little maintenance other than keeping them clean and the movable parts oiled. Do not use the jaws of a vise as an anvil. There is a danger of breaking the jaws or battering the inserts. Never use a pipe to increase the handle leverage, because excessive pressure on the handle may break the handle or jaws.

*Pipe cutters.* A pipe cutter is shown in figure 3-31. Pipe cutters are available in several sizes. The size is usually indicated on the frame of the cutter. A pipe cutter with a range from 1/8 to 2 inches will handle most requirements on the job. Cutters for pipe over 2 inches in diameter usually have two handles to allow two men to rotate the cutter on the pipe. Pipe cutters for cast-iron pipe have special-shaped cutting wheels, and they should not be used on steel pipe. As for maintenance, keep the wheel pins and the threads on the shaft of the handle oiled. When the cutting wheel becomes dull, you should replace it with a new wheel. Keep the tool clean at all times.

*Pipe reamers.* The pipe reamer, shown in figure 3-32, is used to remove the bur from the inside edge of a pipe that has been cut with a pipe cutter. The metal is turned in by the pressure of the cutting wheel and must be removed to prevent restriction to the flow through the pipe after it is installed. Always ream the ends of a pipe when it has been cut by a pipe cutter. Do not store the reamer in a position that may cause the cutting edges to become dull. If the reamer is equipped with a ratchet, it should be kept clean and oiled.

*Pipe dies.* Pipe dies are used to cut threads on pipes. They vary in size. The die set, illustrated in figure 3-33, is used to cut threads from 1/8 to 2 inches.

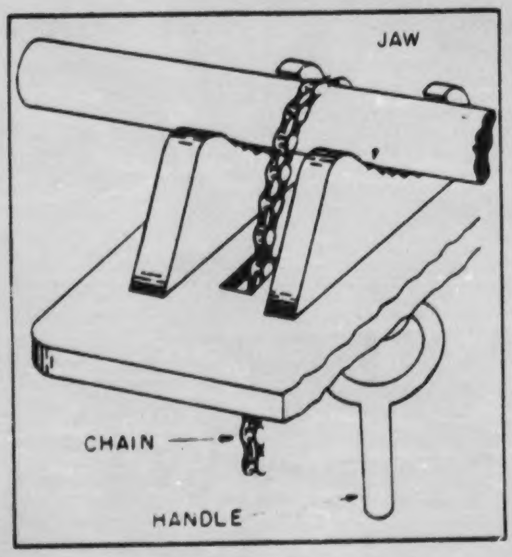


Figure 3-29. Chain vise.

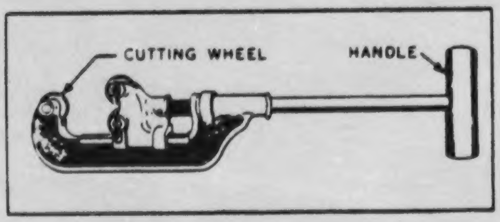


Figure 3-31. Pipe cutter.

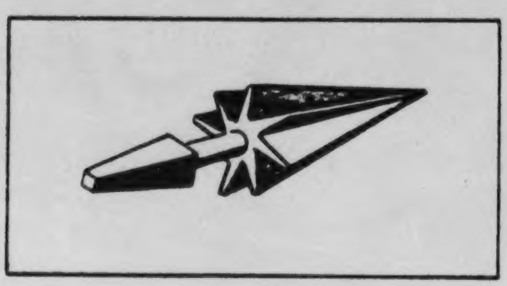


Figure 3-32. Pipe Reamer.

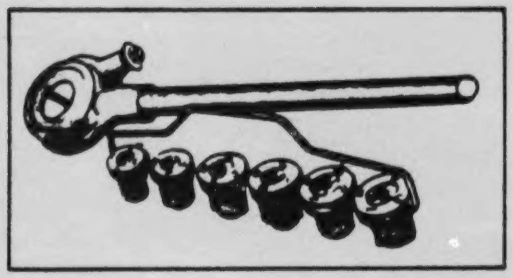


Figure 3-33. Die set.

Larger pipe dies may be geared to cut threads on pipe up to 12 inches in diameter.

A die set consists of a handle, a holder, and a set of dies for different sizes of pipe. Most die holders are designed with a ratchet mechanism to facilitate thread cutting.

Dies are cutting tools and must be handled properly, because they are easily broken. This is due to their brittleness and hardness. Do not attempt to cut threads on hardened material, because it will break, chip, or dull the die. Keep the work well oiled when you are cutting threads on pipe and, when you finish, clean out the chips of metal sticking to the die. Be careful of the sharp slivers cut from the pipe threads. Store the dies in a metal case.

*Tube cutter.* A tube cutter, like the one shown in figure 3-34, is used to cut small sizes of copper tubing and copper pipe. The tool is designed with a frame, handle, rollers, and a cutting wheel. When pipe is to be cut, insert it between the rollers and cutter and apply sufficient pressure to the handle to force the cutting wheel into the pipe. Then rotate the complete cutter around the pipe. A triangular shaped reamer is built on the frame of the cutter. It is used to ream the bur from the inside edge of the tubing.

When you use a tube cutter, be sure that the cutter is sharp and that the shaft is well oiled. Do not try to cut hardened pipe with this cutter. The application of too much pressure on the handle is likely to break the frame.

*Tube bender.* The tube bender is designed to shape and form smooth bends in soft copper tubing and pipe without collapsing the pipe. Figure 3-35 illustrates a small hand tube bender. This tube bender is normally used to bend pipe up to 1/2-inch diameter. When

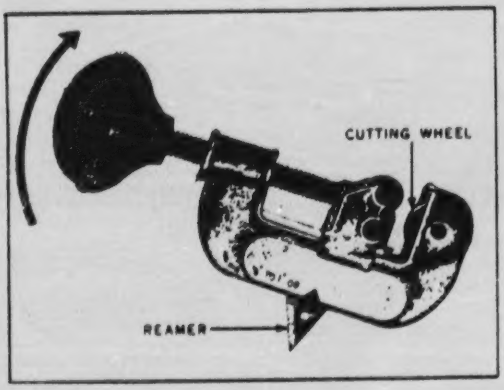


Figure 3-34 Tube cutter.

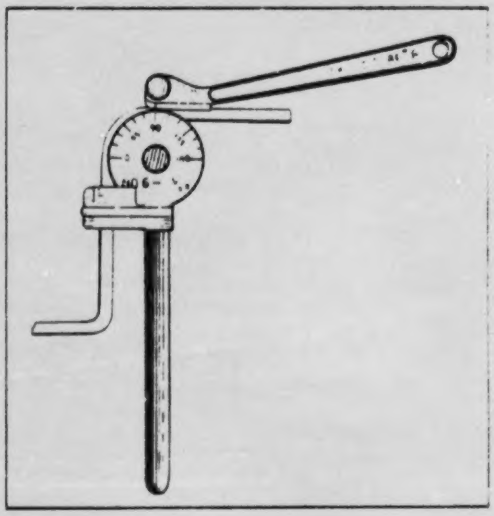


Figure 3-35 Small hand tube bender.

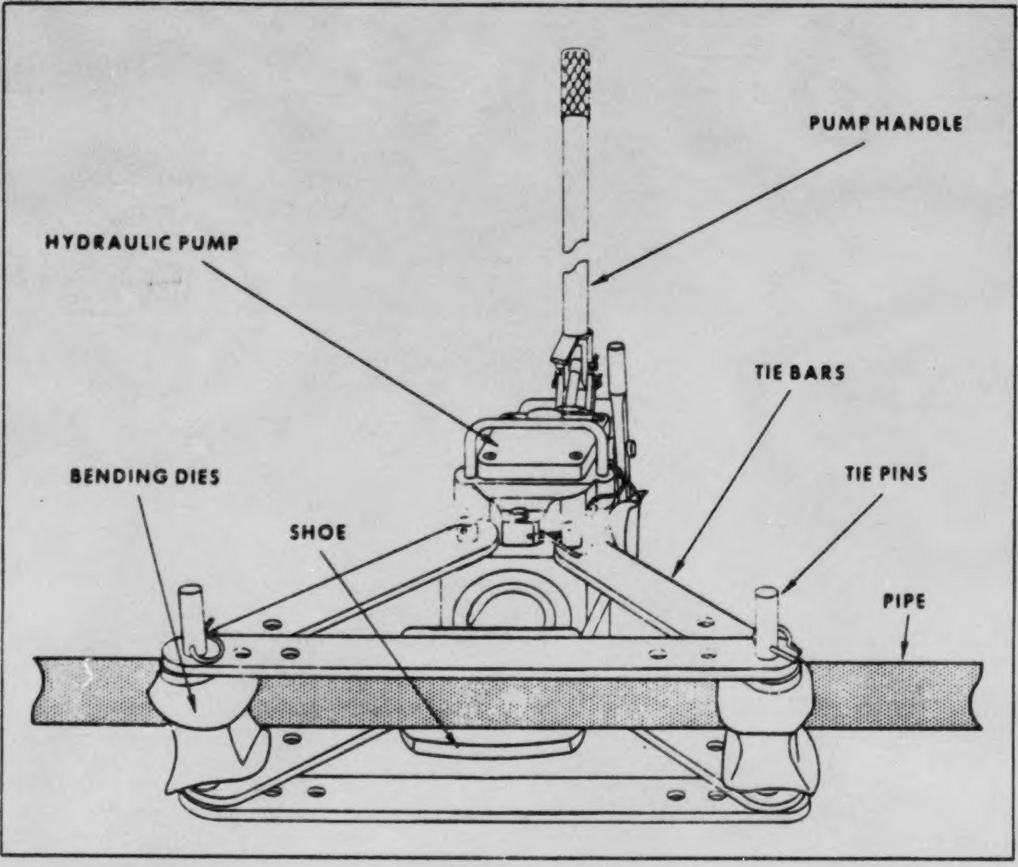


Figure 3-36. Hydraulic tube bender.

bending large pipe, you should use a hydraulic pipe bender like the one shown in figure 3-36. Do not try to bend a section of large pipe with a hydraulic tube bender in one operation, because the tube will collapse.

Bends in steel and wrought-iron pipe must also be made so the pipe will not collapse. Powered tube benders are considered the most practical way to bend steel and wrought iron pipe.

Tube benders for steel and wrought-iron pipe are manufactured in many different sizes and types. Powered tube benders should be used for bending steel and wrought-iron pipe, because they make accurate smooth bends and do not kink, wrinkle, or crush the pipe. Steel and wrought-iron pipe are marked and placed in the tube bender, and the bend is made in the same manner as for other type pipe or tubing.

*Flaring tool.* The flaring tool, shown in figure 3-37,

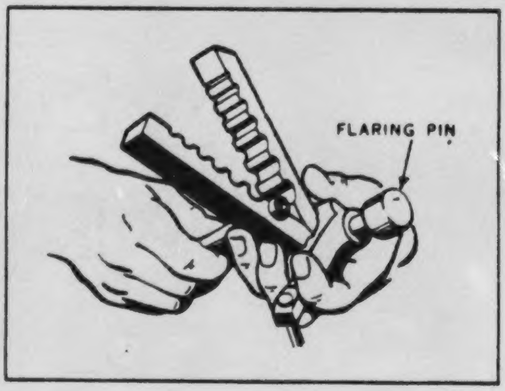


Figure 3-37. Flaring tool.

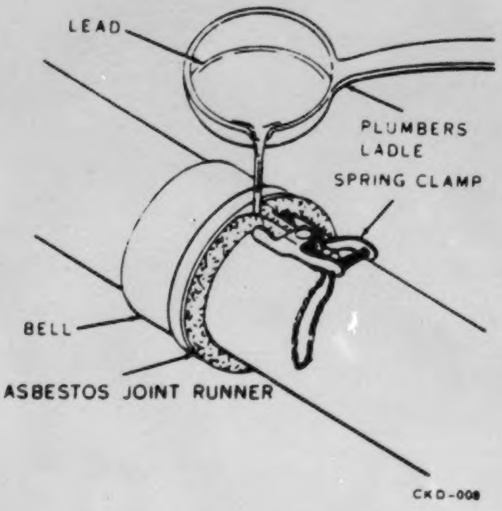


Figure 3-38. Pouring joint using asbestos joint runner.

is used to make flare ends on tubing when flare couplings are used. Assemble the tubing into the proper size of opening in the block. Then slip the clamp on the block so that the flaring pin is positioned directly over the tubing to be flared. Complete the flaring operation by hitting the flaring pin with a hammer. Very little maintenance is required other than keeping the tool clean.

*Joint runners.* Joint runners may be made of asbestos or rubber. They are placed around the pipe next to the bell of a cast-iron soil pipe, when joints are made in horizontal pipe, before lead is poured in the joint. The runner keeps the lead in place inside the bell until it hardens. Figure 3-38 shows a plumber pouring a joint using the asbestos joint runner. The procedure is exactly the same for the rubber joint runner. Joint runners may be used to pour hot bituminous compounds into vitrified clay pipe hub and spigot joints. Many plumbers like to use an asbestos runner that has been soaked in oil. The oil keeps the runner flexible and from sticking to the lead and bituminous material.

*Acetylene torch.* The torch illustrated in figure 3-39 is used to solder copper pipe. It may also be used for other purposes around the job. You should wear goggles when using the torch. Never use acetylene at a pressure greater than 15 pounds per square inch. Never lay the torch down and walk off, leaving it burning. Never transfer acetylene from one cylinder to another. A propane torch is similar to the acetylene torch and is used for soldering small diameter copper tubing. It may also be used to thaw frozen pipe.

*Melting Furnace.* The melting furnace, shown in figure 3-40, is used to melt lead when you are making soil pipe joints. It operates on white gasoline (not leaded). Many of these furnaces have been used in the past. There are still some being used in the Air Force. Another type of melting furnace is one that is operated on propane gas. You saw it in figure 2-2. It is an

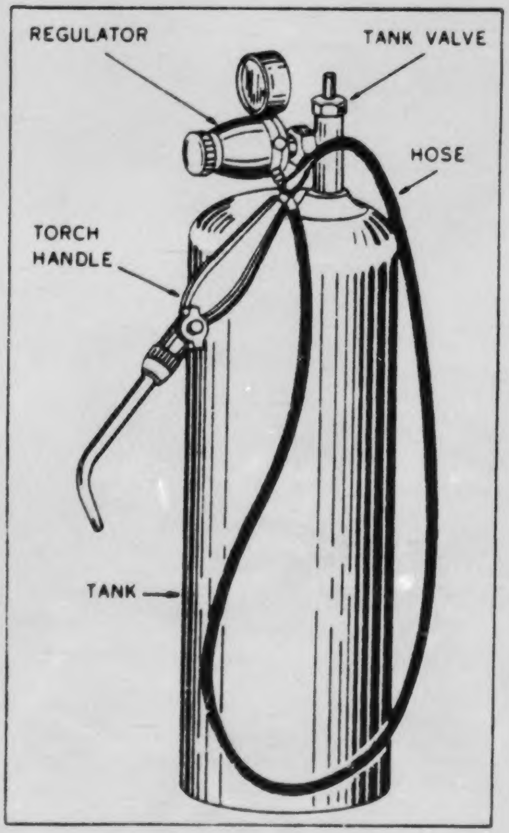


Figure 3-39 Acetylene torch

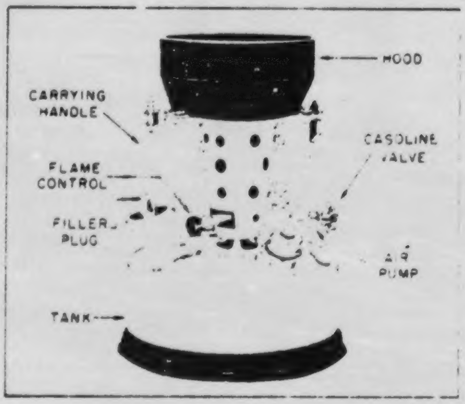


Figure 3-40. Gasoline melting furnace

excellent furnace, and it can be operated on a very low flame. The lead pot and ladle are used in conjunction with the melting furnace. Be extremely careful when using the melting furnace, and always follow the manufacturer's recommendations for its use.

*Lead pot and ladle.* The lead pot, shown in figure 3-41 is used with the melting furnace as a container in which to heat lead. It is placed on top of the melting furnace when in use. A ladle, also shown in figure 3-41, is used to dip the molten lead from the pot and pour it into the joint when you are making soil pipe joints. Although the melting and handling of hot lead in plumbing work is a commonplace procedure, you must take all necessary precautions to avoid being burned.

*Calking irons.* Calking irons are used for setting the lead in cast-iron pipe joints. Different shaped irons, some of which are shown in figure 3-42, are used in calking. Yarning irons are used to pack the oakum into the pipe joint, while calking irons are used to pack the lead. The reason for having so many different calking irons is that each one fits a particular kind of job. For instance, the ceiling calking iron is the only one that can be used to calk a joint next to a ceiling. The calking irons should have a good calking surface and should be sharpened on a bench grinder to maintain an even or angular surface. Coat the irons with a thin film of oil to keep them from rusting.

*Basin wrench.* The basin wrench, illustrated in figure 3-43, is a tool used to turn nuts that are hard to get at: for example, the nuts which connect the water supply line to the faucets under a lavatory or sink. The jaws of the wrench are adjustable over an arc of 180° so that the wrench can be used to loosen nuts as well as tighten them. Make sure that the jaws are clean and sharp and that the movable parts are well oiled. When the teeth become dull, they should be sharpened.

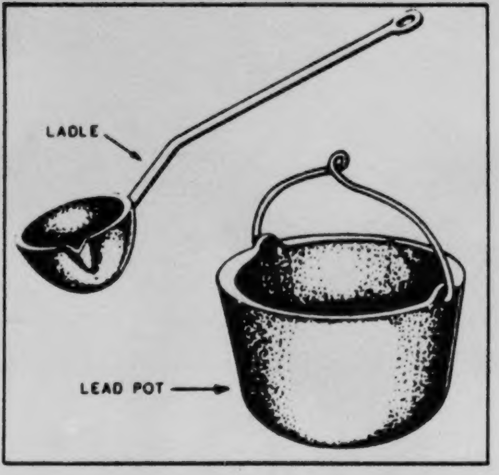


Figure 3-41. Lead pot and ladle.

*Strap wrench.* The strap wrench, illustrated in figure 3-44, is used on brass, copper, and chromium-plated pipes and fittings, because it will not scratch or mar the finished surfaces. It has a thick canvas strap instead of a chain or jaws to grip the pipe. Rosin is applied to the surface of the strap wrench to keep the strap from slipping. Keep the strap wrench clean. Occasionally it is necessary to replace the strap in the wrench.

*Chain tongs.* The chain tongs, shown in figure 3-45, are generally used on pipes and fittings that have a diameter of 2 inches or more. They are placed on the pipe by wrapping the chain around the pipe and attaching it to the wrench by a slot arrangement. One advantage of a chain tong is that it will grip and apply

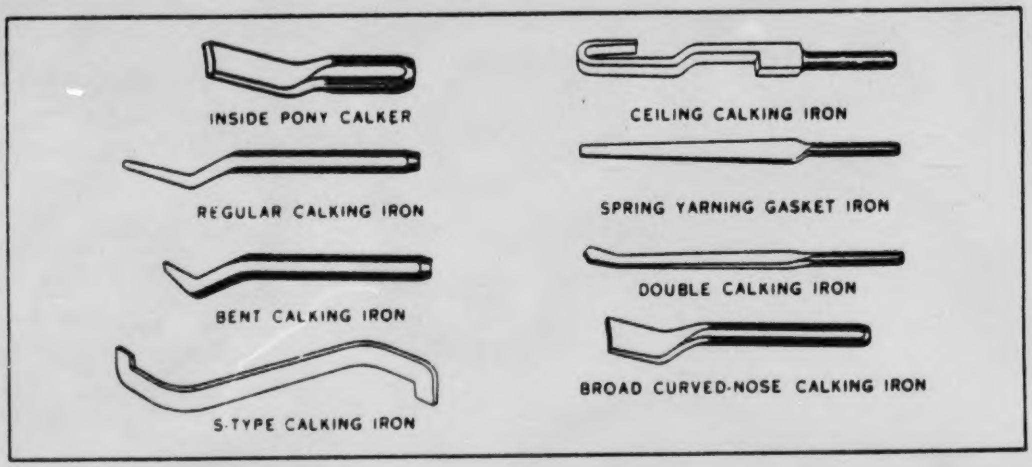


Figure 3-42. Calking irons.

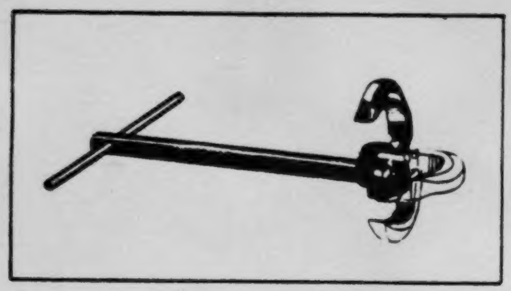


Figure 3-43. Basin wrench.

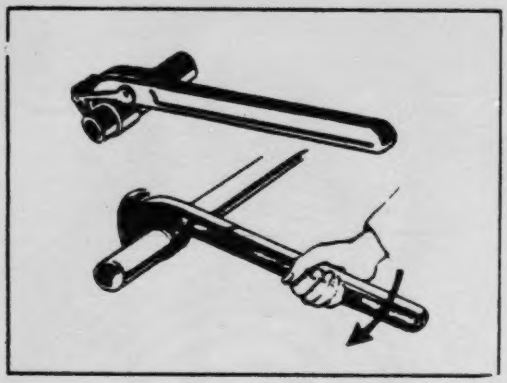


Figure 3-44. Strap wrench.

an even pressure all the way around the pipe or fitting, whereas a large conventional pipe wrench grips the pipe at only two points. The chain tongs are much safer to use than the conventional pipe wrench, because they will not slip off the pipe. Keep the wrench clean and the movable parts well oiled.

*Shovels.* The round-pointed shovels, shown in figure 3-46, are used to remove dirt from trenches and excavations. However, several types of shovels are available, each one having a special purpose in moving earth. For example, you may use a short-handled scoop with a square cutting edge when scooping sand or gravel. After a shovel is used, you should clean it and cover the metal parts with a thin film of oil to keep the surfaces from rusting.

Shovels are usually sharpened with a bench grinder, although a file may be used. Before sharpening a shovel, be sure to straighten and reshape the blade by using a hammer and anvil. Do not use a shovel as a pry bar, because the handle is likely to break and the blade may bend out of shape.

*Earth pick.* The earth pick, illustrated in figure 3-47, is used to loosen soil that has been packed so hard that it cannot be dug with a shovel. The head of the pick has two points: one is rectangular in cross section and tapered to a point, and the other point forms a narrow chisellike blade. Picks are usually sharpened in the shop on a bench grinder, but on the job they may be sharpened with a coarse file.

*Bench grinder.* The bench grinder, shown in figure 3-48, is a tool used for such handgrinding operations as sharpening chisels, screwdrivers, drills, and punches; removing excess metal from work; and smoothing metal surfaces. It is usually fitted with both medium- and fine-grain abrasive wheels. These wheels may be removed and other wheels substituted for them. Such wheels may include wire brushing wheels, buffing wheels, or polishing wheels.

Before you use a bench grinder, make sure that the wheels are firmly held on the spindles by the flange

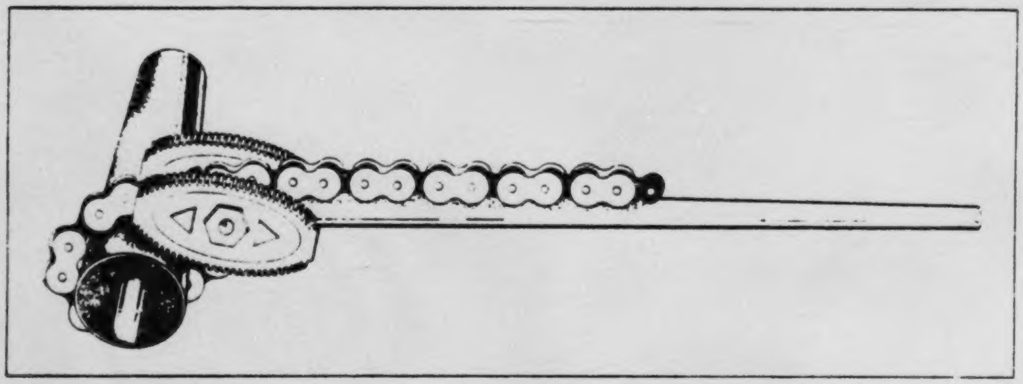


Figure 3-45. Chain tongs.

nuts and that the tool rests are tight. Wear goggles, even if eyeshields are attached to the grinder. It is unsafe to use a grinder without wheel guards. Remember, the abrasive wheel which grinds metal easily, grinds human fingers more easily. The work should be held firmly at the correct angle on the tool rests provided on the grinder and fed into the wheel with enough pressure to remove the desired amount of metal without generating too much heat. Occasionally, cool the edges of the tools being ground to prevent drawing of the temper.

**Exercises (041):**

Complete the blanks in column A, which contains statements related to shop tools, with a letter from column B, which lists the shop tools.

*Column A - Statements*

- ___ 1. Cut threads on pipe.
- ___ 2. Loosen packed soil.
- ___ 3. Tighten nut under lavatory.
- ___ 4. Pack lead in a joint.
- ___ 5. Grip 4'' pipe to screw on fitting.
- ___ 6. Sharpen tool with abrasive wheel.
- ___ 7. Tighten fitting on chrome pipe.
- ___ 8. Solder 2'' copper pipe.
- ___ 9. Make 90° turn in copper pipe.
- ___ 10. Remove bur from inside edge of pipe.

*Column B - Shop Tools*

- *a.* Pipe vise.
- *b.* Pipe cutter.
- *c.* Pipe reamer.
- *d.* Pipe dies.
- *e.* Tube cutter.
- *f.* Tube bender.
- *g.* Flaring tool.
- *h.* Joint runner.
- *i.* Acetylene torch.
- *j.* Melting furnace.
- *k.* Lead pot and ladle.
- *l.* Caulking iron.
- *m.* Basin wrench.
- *n.* Strap wrench.
- *o.* Chain tongs.
- *p.* Shovel.
- *q.* Pick.
- *r.* Bench grinder.

**042. Given a list of statements and a list of special tools, choose the tool most appropriate for each statement.**

**Special Tools and Equipment.** As a plumber, you must be able to recognize the need for special purpose tools and equipment should the occasion arise. For example, a mess hall is equipped with a combination hot and cold water faucet that is leaking. A special tool was supplied by the manufacturer to tighten the packing nut. Your job will be very easy if that special tool is available to you. If it isn't, a 10-minute job could turn out to be a major job. In this section, we will cover some special tools and equipment that you may use on your job.

*Vacuum plunger.* Sometimes the term "plumber's friend" is used to describe the vacuum plunger which is shown in figure 3-49. You place the cup over the fixture drain. By pushing and pulling on the handle, you create alternate pressure and suction cycles. Obstructions such as lint, hair, fats, food particles, and other objects are worked loose and flushed down the drain. The vacuum plunger is designed to clear drains of fixtures such as kitchen sinks, lavatories, and bathtubs. These fixtures have flat areas in the bottom around the drain.

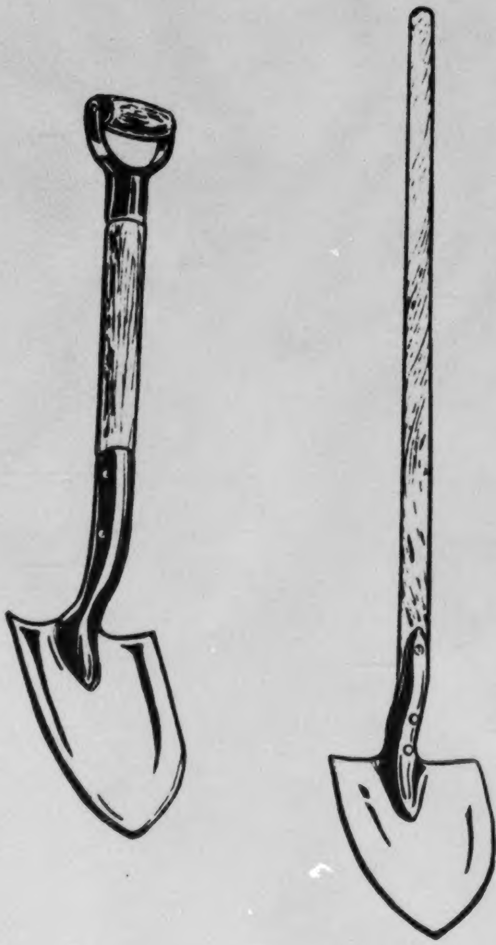


Figure 3-46. Shovels.

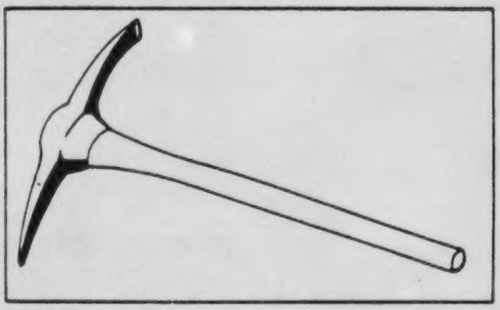


Figure 3-47. Earth pick.

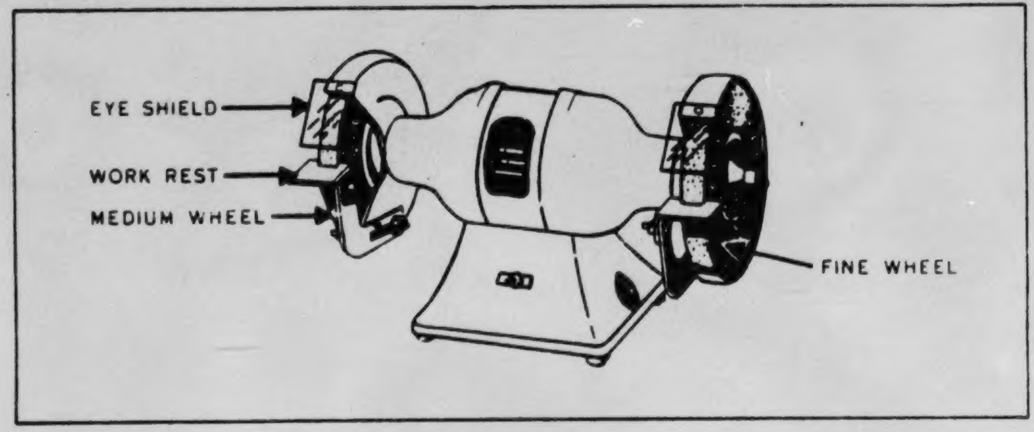

EYE SHIELD
WORK REST
MEDIUM WHEEL
FINE WHEEL

Figure 3-48. Bench grinder.

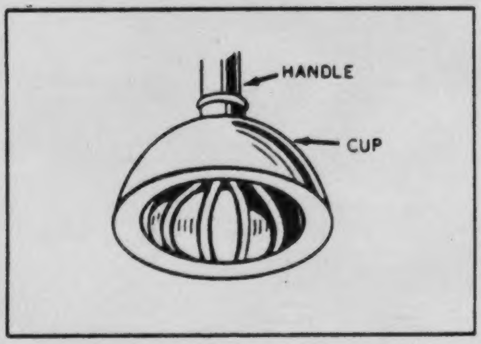


Figure 3-49. Vacuum plunger.

*Force cup.* A similar tool called a force cup, see figure 3-50, is used on fixtures such as water closet bowls and wall-hung urinals that have integral traps. These fixtures have cone-shaped bottoms that enable the force cup plunger to be more effective than the vacuum plunger. To achieve the best results with a force cup, insert it down into the outlet of the fixture with the fixture filled with water as near the top as possible. Alternate pushing and pulling strokes of the handle should work the obstruction loose and flush it down the drain. Do not use this method of clearing a stoppage when it is suspected that a large or irregular-

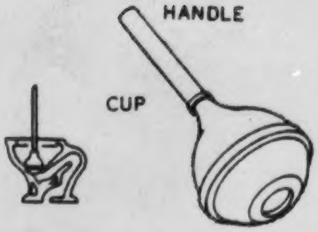


Figure 3-50. Force cup.

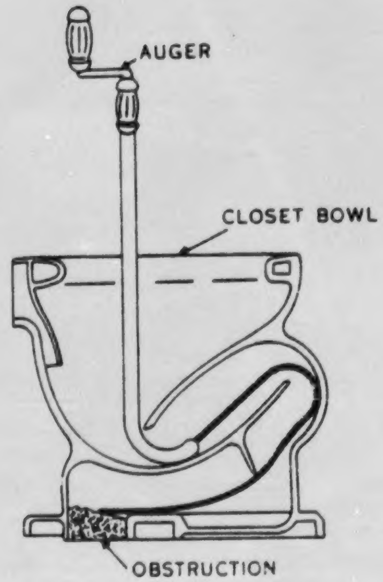

AUGER
CLOSET BOWL
OBSTRUCTION

Figure 3-51. Using a closet auger to clear a water closet trap

shaped object is the cause of the stoppage. Forcing such an object into the sewer may cause an underground stoppage which could be more difficult to clear than the stoppage of the fixture.

*Plumber augers.* Several special augers have been designed to aid the plumber in removing stoppages from fixtures and pipes. These augers are often referred to as snakes. The closet auger is used if the obstruction cannot be forced through the trap by plunging. Insert the end of the flexible cable in the trap, forcing it through the trap while rotating the handle, see figure 3-51. Rotate the handle continuously until the auger reaches the obstruction and then turn the handle slowly until the obstruction is caught on the coiled hook of the auger. Continue rotating the handle in the same direction (clockwise) and slowly withdraw the auger from the bowl, removing the obstructing object if possible rather than forcing it through to the soil piping.

If the obstruction cannot be removed from the water closet trap with the force cup or the closet auger, the closet bowl must be removed and the obstruction forced out from the other end of the trap.

A special tool used to remove obstructions from building drains and sewers is the ribbon snake shown in figure 3-52. It may also be used to remove other stoppages.

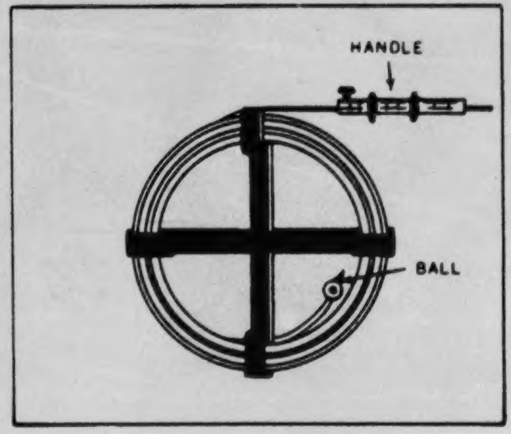


Figure 3-52. Ribbon snake.

Sewer mains with obstructions can be opened using a power-driven sewer auger as shown in figure 3-53. Use a J-tube as a guide when inserting the cable into the sewer main. The head of the auger may be either the punch or cut type. It will punch or cut the obstruction allowing water to flow downstream. The obstruction can become entangled in the auger head permitting the obstruction to be withdrawn from the sewer pipe. A sink auger, shown in figure 3-54, is used to unclog a sink or lavatory drain.

*Test plug.* Use a test plug to seal open ends of a soil pipe installation before you fill the pipe with water for testing the joints for leaks. A test plug is shown in figure 3-55. The plug consists of a wide flexible rubber spreader which is set between two metal discs. By turning the wing nut, the metal discs are forced together by means of a sleeve. The rubber is forced firmly against the pipe marking a tight seal.

*Fiber pipe tapering tool.* The fiber pipe tapering tool, shown in figure 3-56, is used to cut a 2° taper on fiber pipe for making joints. It is designed with a center guide, which is fitted inside the pipe end to be tapered,

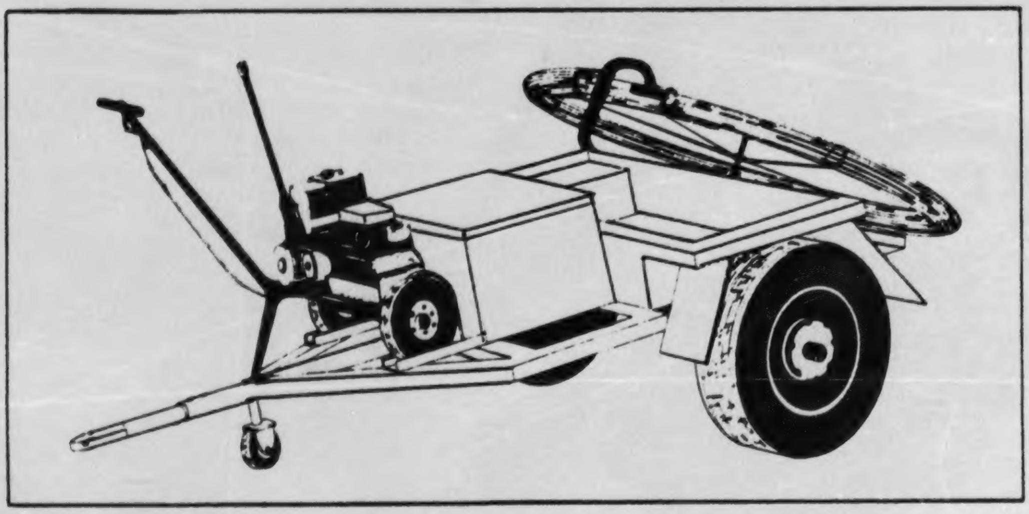


Figure 3-53. Power-driven sewer auger.

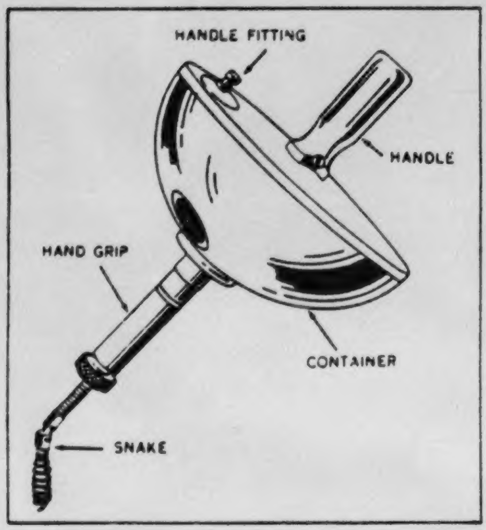


Figure 3-54. Sink auger.

and adjusted with the expander handle. The cutter is then set at the proper position and the lathe handle rotated; this action causes the blade to shave off the pipe end to a 2° bevel.

*Water main self-tapping machine.* The water main self-tapping machine shown in figure 3-57 is a specialized tool used for tapping a water main under pressure. It consists of a body, which straps around the pipe to be tapped; a butterfly valve, which can be opened and closed as needed; and an upper section, which is rotated to tap the pipe. By using this machine, you can tap a hole in a water main under pressure and install a corporation stop without losing over a quart of water.

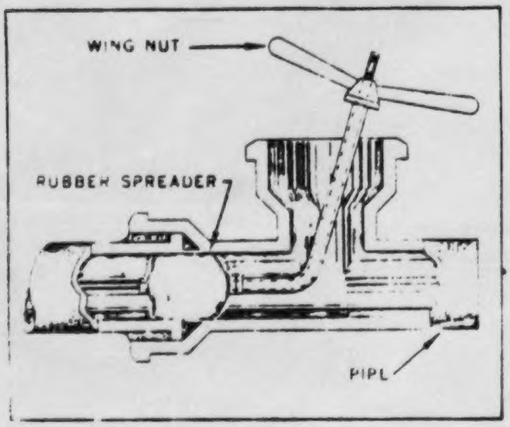


Figure 3-55. Test plug.

**Exercises (042):**

A statement of a problem is made in column A. Think of possible trouble that may exist and select a tool from column B that may help you solve the problem.

*Column A - Statements*

1. Water is filling the manhole outside the building.
2. A kitchen sink is operating, but the water drains slowly.
3. A wall-hung urinal with a cone-shaped bottom is draining slowly.
4. The building drain has a partial stoppage. A cleanout plug is located in the hall.
5. A corporation stop is needed in a water main.

*Column B - Special Tools*

Vacuum plunger
Force cup.
Ribbon snake.
Sewer auger.
Sink auger.
Test plug.
Tapering tool.
Self-tapping machine.

## 3-2. Care of Tools

Knowing about the various tools is, of course, essential to your work as a plumber. But unless you know how to clean, lubricate, sharpen, and maintain these tools, you cannot completely succeed as a plumber. You must know exactly where they are at all times. You must know how to keep them in good condition, and you must have a desire to keep them in good operating condition.

**043. Answer questions related to maintenance of plumbers' tools and equipment.**

**Lubrication.** Tools and equipment that have operating parts should be lubricated as needed. The construction of the equipment determines the procedure for lubricating the parts. Some power equipment is fitted with grease fittings for a grease gun, and some has oil cups for applying oil with an oil can. Other equipment is lubricated just by applying oil to the moving parts. One point to keep in mind is not to overlubricate; do not apply grease or oil to such an extent that it will run out of the unit and collect dirt and grit. If an excessive amount of lubricant is applied, remove it with a cloth. It is important to lubricate a moving part as often as necessary, and it is also important that excessive amounts of oil or grease be removed for reasons of cleanliness.

Small tools that are to be stored for any period of time must be coated with a thin layer of lubricant to prevent rusting. Metal parts of tools should be cleaned to remove fingerprints before they are coated with oil. Handling tools will cause them to rust if they are not cleaned before they are coated with oil. A good way to oil tools before they are stored is to apply the oil with an oil-soaked rag. Ordinarily, these rags have been saturated with a light grade of engine oil (SAE No. 10). When tools are to be stored for a long period of time, you should apply a rust-preventive compound to the metal parts of the tools. It is good practice to apply linseed oil to the wooden parts of tools before they are stored. The linseed oil will soak into the wood and preserve it. It will also prevent moisture from entering the wood.

**Maintenance of Handtools.** *Maintenance and Care of Handtools* is the title of TO 32-1-101. It is available to you in the CE library. Another good reference is TO 32-1-171, *Engineer Handtools.* These TOs are excellent references. To complete the exercises, however, this text is all you need. We covered a certain amount of maintenance in the past three objectives; you may have to refer to them to answer the questions correctly. Since we did not cover long-term storage of tools, let's do so now.

When tools are stored for a long period of time, the box in which the tools are stored should be raised off the wood or cement floor so that air can circulate under the box. In this way, the dry circulating air will reduce the moisture content in the box and will help keep the tools from rusting.

**Exercises (043):**

Refer to all of the prior written material in this chapter and answer the following questions (briefly) relative to plumbers tools and equipment.

1. What should you do with a pipe wrench that has dull jars?

2. The adjustable jaw wrench in your toolbox is in good condition. What maintenance should you perform on it as you use the wrench daily?

3. You have a chisel with a mushroomed head. Is maintenance required? _________ If yes, how?

4. A strap wrench slips. What maintenance is required?

5. Is it possible to overlubricate tools? ______ If yes, how is overlubrication handled?

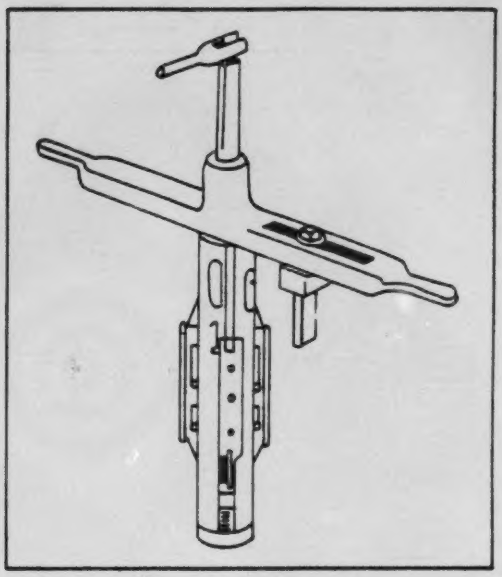


Figure 3-56. Fiber pipe tapering tool.

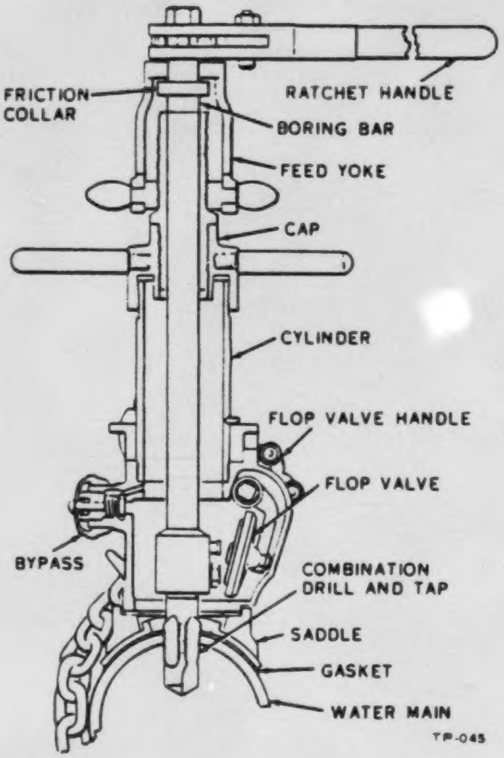


Figure 3-57. Water main self-tapping machine.

**044. Given statements of procedures for sharpening plumbing tools, distinguish those that are correct and safe from those that are unsafe.**

**Sharpening of Cutting Tools.** Sharpening of handtools was covered previously in this chapter during discussion of the particular tool. Review the material on sharpening plier teeth, sharpening the nibs and lips of an auger bit, sharpening a screwdriver bit, and sharpening a cold chisel.

Most of the tools you use do not require sharpening. However, occasionally they may become nicked and will require resharpening. This can be done easily on a bench grinder; or if the nick is not too large, it can be eliminated with a file.

**Exercises (044):**

1. Mark the following statements with a (C) for correct and safe procedure and a (U) for unsafe and incorrect procedure. Place the letter in the blank provided.

____ *a.* Remove a nick in a shovel with a rasp.

____ *b.* To preserve the temper, dip the chisel in water frequently during sharpening.

____ *c.* Sharpen the nibs and lips of an auger bit with a file.

____ *d.* Move the file toward the cutting edge of a tool being sharpened.

2. Briefly explain the procedure for sharpening a chisel for cutting tough metal.

## 3-3. Maintenance of Shop Equipment

You will have to wear protective equipment quite frequently when you maintain shop tools and equipment. The primary protective equipment that you will be wearing are goggles and gloves. They should be worn when needed to protect your eyes from flying particles; and gloves protect your hands from sharp or rough edges, hot metal, cold metal, or wood splinters.

Keep the goggle lenses clean and protected when they are not being used. Tighten the screws which hold the frame and keep the lenses tight in the frame. If the frame gets broken, replace the goggles.

Gloves must be cleaned or replaced if they get muddy or dirty. Clean leather gloves with saddle soap; this will prevent the leather from becoming stiff. After they are cleaned, inspect them for ripped and torn places. To protect the gloves, coat them with neat's-foot oil. Do not use lubricating oil on leather gloves, because it will cause them to crack. When the gloves become worn and damaged, turn them in to supply for a new pair. Remember, this protective equipment is made for your protection. Wear it when using and maintaining shop tools and equipment.

**045. Given a hypothetical problem situation relative to maintenance of shop equipment, solve the problem.**

**Routine Maintenance of Shop Equipment.** All tools and equipment require a certain amount of routine maintenance. In some cases the maintenance is simply cleaning and applying oil to prevent rusting. In other cases, maintenance may require applying a torque wrench to certain bolts. Obviously in a text of this type, detail maintenance procedures for each piece of equipment that you use is not feasible. For example, maintenance procedures on just the abrasive wheel of your bench grinder requires three pages of coverage in TO 32-1-101. The TO states that you must not force the wheel on the spindle. It must slide on easily with 0.003- to 0.005-inch clearance. Also you must tighten the spindle nut just enough for the flanges to hold the wheel firmly. It states that overtightening may crack the wheel. Check the wheel for cracks by tapping it with a cellulose face or rubber face hammer or mallet. A ringing sound indicates a satisfactory wheel. A dull sound indicates a cracked wheel. Do not use a cracked wheel as it may fly apart and injure you.

Maintenance of shop equipment is written in TOs and manufacturer's manuals. Often critical maintenance items are written on the equipment. For example, "Use SAE 10 oil. Change oil each 50 hours of operation." "Do not operate equipment during adjustment." You have heard the term "Safety First" many times in the past. SAFETY FIRST is Air Force policy. Your safety and the safety of Air Force equipment comes before getting the work done. In the long run, much more work is accomplished when equipment is maintained properly and when safety is a prime consideration. Use common sense as you apply rules of maintenance. The tone of the rule often implies a tolerance.

**Exercises (045):**

1. From the following problem situation in which you are in charge of the job, tell what you would do to solve the problem.

   *Problem Situation:* You are operating a gasoline powered sewer auger to remove a stoppage. If the stoppage is not removed, sewage will overflow into a housing area in about 1 hour. According to the maintenance records, the oil much be changed each 50 hours. At oil change time, periodic maintenance is also performed on the equipment. This maintenance requires 2 hours. The 50-hour oil change period is due now. As the NCO in charge, what will you do?

2. You are using an abrasive wheel dresser to dress the face of a bench grinder. What primary protective equipment should you wear?

# MODIFICATIONS

Chap. Nos. 4 & 5 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

## CHAPTER 2

| | |
|---|---|
| 024 - 1. | ______ |
| 024 - 2. | ______ |
| 024 - 3. | ______ |
| 024 - 4. | ______ |
| 024 - 5. | ______ |
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| 024 - 7. | ______ |
| 024 - 8. | √. |
| 025 - 1. | X. |
| 025 - 2. | ______ |
| 025 - 3. | X. |
| 025 - 4. | ______ |
| 025 - 5. | X. |
| 025 - 6. | ______ |
| 025 - 7. | X. |
| 026 - 1. | X. |
| 026 - 2. | X. |
| 026 - 3. | X. |
| 026 - 4. | √. |
| 026 - 5. | X. |
| 026 - 6. | √. |
| 026 - 7. | √. |
| 027 - 1. | √. |
| 027 - 2. | ______ |
| 027 - 3. | √. |
| 027 - 4. | ______ |
| 027 - 5. | √. |
| 027 - 6. | ______ |
| 027 - 7. | ______ |
| 027 - 8. | √. |
| 028 - 1. | T. |
| 028 - 2. | F. |
| 028 - 3. | T. |
| 028 - 4. | F. |
| 028 - 5. | T. |
| 028 - 6. | T. |
| 028 - 7. | T. |
| 028 - 8. | F. |
| 028 - 9. | F. |
| 028 - 10. | T. |

029 - 1. a. Use propane melting furnace.

b. Welding equipment is not made for heating a melting pot. The gasoline melting furnace is dangerous, especially when used by an apprentice.

029 - 2. a. Read the labels to select the best compound for the job.

b. Apply the compound to the pipe as described by the manufacturer and remove the oil and grease from the pipe.

030 - 1. U.
030 - 2. S.
030 - 3. S.
030 - 4. S.
030 - 5. U.

031 - 1. a. D.
b. C.
c. A.
d. B.
031 - 2. Water, soda-acid, foam.
031 - 3. Foam, $CO_2$, dry chemical.
031 - 4. Dry powdered chemical.

032 - 1. a. U.
b. U.
c. S.
d. U.
e. S.

033 - 1. a. X.
b. ✓.
c. X.
d. ✓.
e. ✓.

034 - 1. a. S.
b. U.
c. S.
d. U.
034 - 2. c, d, b, a, e.

035 - 1. a. Z.
b. Y.
c. X.
d. Y.

036 - 1. a. Yes.
b. Yes.
c. No.
d. Yes.
e. Yes.
036 - 2. Grasp the ladder by the rungs when you walk under it to erect it.

037 - 1. 1. e.
2. d.
3. g.
4. f.
5. b.
6. a.
7. c.

038 - 1. a. C.
b. I.
c. I.
d. I.
e. C.
f. I.
038 - 2. Discarded.

039 - 1. U.
039 - 2. S.
039 - 3. U.
039 - 4. U.
039 - 5. U.
039 - 6. S.

## CHAPTER 3

040 - 1. b.
040 - 2. a.
040 - 3. n, g.
040 - 4. m, g, i.
040 - 5. n, q, k.
040 - 6. a.
040 - 7. n, f, j.
040 - 8. c, e.
040 - 9. o.
040 - 10. l.

041 - 1. d.
041 - 2. q.
041 - 3. m.
041 - 4. l.
041 - 5. o.
041 - 6. r.
041 - 7. n.
041 - 8. i.
041 - 9. f.
041 - 10. c.

042 - 1. Sewer auger.
042 - 2. Vacuum plunger.
042 - 3. Force cup.
042 - 4. Ribbon snake.
042 - 5. Self-tapping machine.

043 - 1. Sharpen them with a grinder or a file.
043 - 2. Keep the wrench clean and the movable parts oiled.
043 - 3. Yes. Remove the mushroomed portion with a bench grinder.
043 - 4. Apply rosin to the strap.
043 - 5. Yes. Remove excess oil or grease with a cloth.

044 - 1. a. U.
b. C.
c. C.
d. U.
044 - 2. Sharpen chisel to an angle of 90° with a bench grinder. Dip the chisel in water frequently during grinding.

045 - 1. Continue operating the auger until the stoppage is removed. After the sewer problem is solved, change the oil and perform the periodic maintenance.
045 - 2. Goggles to protect your eyes from flying particles.

## MODIFICATIONS

Pages 138 – 144 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

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**STOP–** **1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.** **2. USE NUMBER 1 OR NUMBER 2 PENCIL.**

55255 01 24

## EXTENSION COURSE INSTITUTE
## VOLUME REVIEW EXERCISE

CAREER ORIENTATION, SUPERVISION, AND RESOURCE MANAGEMENT

Carefully read the following:

*DO'S:*

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that numerical sequence on answer sheet alternates across from column to column.
3. Use a medium sharp #1 or #2 black lead pencil for marking answer sheet.
4. Circle the correct answer in this test booklet. After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

*DON'TS:*

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #1 or #2 black lead pencil.

*NOTE:* NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed*. Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

29. (024) What precautions should be taken to prevent a buildup of harmful vapors in an inclosed work area?

    a. Close windows.
    b. Close exit doors.
    c. Insure proper ventilation.
    d. Insure proper temperature is maintained.

30. (025) Why is a box-end wrench preferred over an open-end wrench?

    a. More convenient.
    b. Produces less slippage.
    c. Provides more leverage.
    d. Less turning room required.

31. (027) What is used to test an acetylene tank for a leak?

a. Soapy water.
b. Striker.
c. Match.
d. Wet rag.

32. (028) After opening a manhole, what is the minimum distance the lid should be placed from the open hole?

a. 1 foot.
b. 2 feet.
c. 3 feet.
d. 4 feet.

33. (029) Which of the following is the most efficient type of fuel to use in a melting furnace?

a. Liquefied petroleum gas.
b. Acetylene.
c. Gasoline.
d. Natural gas.

34. (030) What controls the gas going to the main burner of a water heater?

a. Adjustment nut.
b. Thermocouple.
c. Thermostat.
d. Pilot.

35. (030) What is the proper setting for a temperature and pressure safety valve on a standard water heater?

a. 75 pounds and 132° F.
b. 100 pounds and 180° F.
c. 125 pounds and 210° F.
d. 150 pounds and 242° F.

36. (031) What type of extinguisher is used on a Class D fire?

a. Foam.
b. Water.
c. Carbon dioxide.
d. Dry-powdered compound.

37. (032) What are the main hazards caused from improper grounding of power tools?

a. Fire and shock.
b. Overloading and burnout.
c. Damaged motors and ignition.
d. Explosion and personal injury.

38. (033) What protective equipment should be used when operating power equipment in damp areas?

a. Insulated boots and leather gloves.
b. Asbestos shoe liners and gloves.
c. Wet ground and gloves.
d. Rubber mat and gloves.

39. (034) The safest way to pick up a heavy object is to bend the legs about

a. 30° at the knees and squat.
b. 45° at the knees and crouch.
c. 60° at the knees and squat.
d. 90° at the knees and crouch.

40. (035) Which of the following can be effectively used as a portable work platform?

a. Extension ladder.
b. Stepladder.
c. Single rail ladder.
d. Double rail ladder.

41. (036) Before you climb a 24-foot extension ladder, you should make sure that the bottom of the ladder is at least

a. 6 feet from the building.
b. 8 feet from the building.
c. 12 feet from the building.
d. 16 feet from the building.

42. (038) Which is the proper way for one man to carry an extension ladder?

a. Over the shoulder with the rear end elevated.
b. Suitcase style with rear end elevated.
c. Over the shoulder with front end elevated.
d. Suitcase style with front end elevated.

43. (039) What is required for an aluminum stairway scaffold three sections high?

a. Install outrigger supports to first section.
b. Install guard wires to first section.
c. Install outrigger supports to all sections.
d. Install guard wires to all sections.

44. (040) You have to unscrew a nut from a 3/4-inch bolt. The following tools are available. What is the best tool to use?

a. Slip-joint pliers.
b. Water pump pliers.
c. Small pipe wrench.
d. Adjustable jaw wrench.

45. (041) What tool is used to remove burrs from the inside edge of pipe?

a. Dies.
b. Reamer.
c. Torch.
d. Flare.

46. (041) What is the purpose of a joint runner?

a. To screw pipes to fittings.
b. To measure cast-iron pipe during fabrication.
c. To prevent lead from flowing out of cast-iron joints.
d. To hang cast-iron and vitrified clay pipe to ceiling joists.

47. (041) Yarning irons are used to calk

a. lead.
b. oakum.
c. copper.
d. cement.

48. (041) Which one of the following tools is a plumber's shop tool?

a. Chain tongs.
b. Ribbon snake.
c. Crosscut saw.
d. Brace and expansion bit.

49. (042) To remove obstructions such as lint and hair from a fixture, you should first use a

a. sink auger.
b. ribbon snake.
c. vacuum plunger.
d. jay (J) wire.

50. (042) Which one of the following tools is a plumber's special tool?

a. Force cup.
b. Joint runner.
c. Calking iron.
d. Adjustable jaw wrench.

51. (042) What is used to seal the open end of a soil pipe before checking for leaks?

a. Wood plug.
b. Test plug.
c. Round ball.
d. Pressure disc.

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52. (042) What is the purpose of a self-tapping machine?

    a. To tap calking in hard-to-get-at areas.
    b. To tap square holes in metallic pipe.
    c. To make multiple holes in pipes for drainage fields.
    d. To tap a water main under pressure and install a corporation stop.

53. (043) What TO is titled Maintenance and Care of Handtools?

    a. TO 32-1-101.
    b. TO 42-1-101.
    c. TO 52-1-101.
    d. TO 82-1-101.

54. (045) From the following, select the term that best describes the sound that indicates a cracked bench grinder wheel.

    a. Dull.
    b. Firm.
    c. Deep.
    d. Ring.

5.8.

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CDC 55255

# PLUMBING SPECIALIST

(AFSC 55255)

Volume 2

*Waste Systems*

Proficimus More Irretenti

Extension Course Institute

Air University

PREPARED BY
DEPARTMENT OF CIVIL ENGINEERING TRAINING
USAF SCHOOL OF APPLIED AEROSPACE SCIENCES (ATC)
SHEPPARD AIR FORCE BASE, TEXAS

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EXTENSION COURSE INSTITUTE, GUNTER AIR FORCE STATION, ALABAMA

THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL
OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES
ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

# Preface

THIS SECOND volume of CDC 55255, *Plumbing Specialist*, will provide you with the information necessary to install and maintain waste systems. You will learn about sewer systems and waste disposal; structural openings; building drains; stacks and vents; roughing-in vents and waste lines; measuring, cutting, threading, and assembling pipe; and inspection and maintenance of waste systems.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTOX, Sheppard AFB TX 76311. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 18 hours (6 points).

Material in this volume is technically accurate, adequate, and current as of September 1975.

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## CHAPTER 1

**NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.**

# Sewer Systems and Waste Disposal

THE HOUSE SEWER is that part of a sewer that carries waste water, sewage, or other drainage from the building drain system to the street sewer or other place of disposal. Usually, the sewer system is installed at a specific fall or grade so that it may carry off the sewage by gravity flow. In some cases, when the house sewer is below the main sewer, various types of waste disposal equipment must be used to lift the sewage into the main sewer.

In isolated areas where there are no community sewer systems, it is necessary to install a disposal unit that can treat small quantities of waste and sewage. Such a unit consists of a septic tank and disposal bed. It will take care of a limited amount of waste.

This chapter covers terms associated with plumbing; the different types of sewer systems; methods of constructing and grading sewer trenches, thimbles, and sump pumps; and procedures for backfilling sewer trenches. It also covers the methods of sewage disposal and septic tank construction.

### 1-1. Exterior Sewer Systems

As a plumbing specialist there are many plumbing terms with which you must be familiar. A familiarity with them will give you a better understanding of the plumbing profession and will enable you to do your job in a more proficient manner. We have included these terms in a glossary at the end of this volume. You should refer to the glossary for an explanation of terms you do not fully understand.

There are two different types of sewer systems: storm sewers and sanitary sewers. A storm sewer is used to convey only rainwater, subsurface water, condensate, cooling water, or other similar wastes. A sanitary sewer is used to carry liquid or waterborne waste from plumbing fixtures to the house sewer and into the main sewer lines. Sanitary sewers are usually separate systems and are not connected to storm sewers. They are not connected because the discharge from sanitary sewers must be treated before it is dumped into a stream or lake. This requirement is not

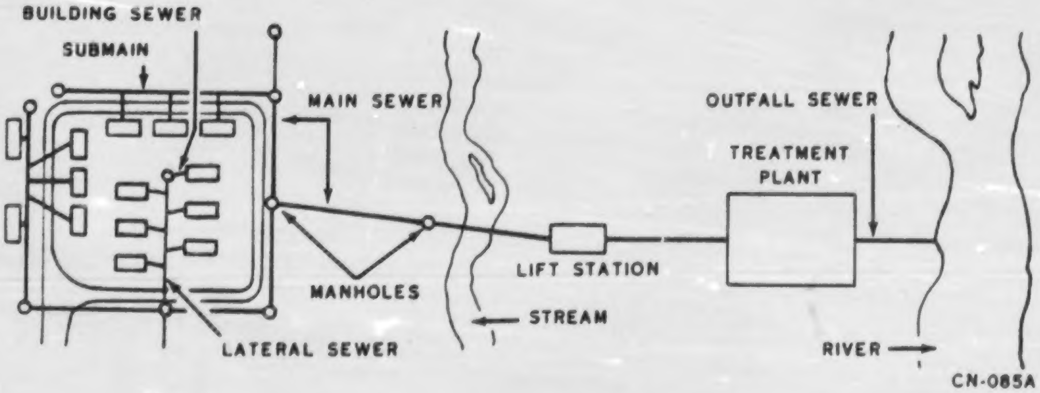

Figure 1-1 Typical exterior sewer system.

necessary for the discharge from storm sewers because its discharge is merely runoff water.

## 200. Identify the components of an exterior sewer system.

**Components of Sanitary Sewer System.** A sanitary sewer system carries sewage from industrial and residential areas. The sanitary sewer network includes building sewers, lateral sewers, submains, sewer mains, outfall sewer, manholes, lift stations, and treatment plant. Figure 1-1 is an illustration of a typical sanitary sewer system. Refer to figure 1-1 as you read the description of the components of a sanitary system.

*Building sewer.* The building sewer, sometimes called the house sewer, is that part of the exterior waste system extending from a minimum of 3 feet outside the building wall to a public sewer, private sewer, individual sewage-disposal system, or other point of disposal.

*Lateral sewer.* A lateral is that portion of the sewer system normally found in the street or alley. It receives discharge from building sewers and carries it to the submain or sewer main.

*Submain.* A submain is a sewer main which receives discharge from two or more lateral sewers, and carries a sewer main.

*Sewer main.* A sewer main receives discharge from building sewers, lateral sewers, and submains and carries it to a septic tank or treatment plant.

*Outfall sewer.* The outfall sewer is the main sewer which receives discharge from the treatment plant and carries it to the place of final disposal, such as a stream or river.

*Manhole.* A manhole is a constructed opening in sewer lines. Maintenance crews must remove covers from the manholes to gain access to the sewer mains. Manholes are usually placed at intervals in sewer mains of not more than 300 feet.

Manholes are located at all junctions, at changes of direction, at changes in slope, at changes in elevation, and at the end of each lateral. For junction manholes check which upstream invert is critical in determining outlet inverts to keep manhole above flooding level. Take special care against infiltration due to depth or proximity of surface water.

*Lift stations.* A slight fall of a piping system permits the waste-bearing water (sewage) to flow. Objects such as hills, rivers, streams, and extended distances, require the sewage to be pumped to higher elevations so that the flow may be continued to the point of disposal. The pumps you installed in the sewer systems are called lift stations.

*Treatment plants.* All untreated sewage (raw sewage) terminates at the treatment plant. Raw sewage is filtered to remove articles that will not dissolve during the treatment process. After the sewage has been through the different processing chambers, it is conveyed through a final chamber (contact chamber) where the water is treated to remove bacteria and disease-bearing germs. The water is then returned to lakes, streams, and rivers, where it can be reused.

**Exercise (200):**

1. Without referring back to the text, identify the components of an exterior sewer system, using the following code. Place the two letter codes in the space provided on figure 1-2.

BS = Building sewer.
LS = Lateral sewer.
SM = Submain.
MS = Main sewer.
OS = Outfall sewer.
MH = Manhole.
PS = Lift station.
TP = Treatment plant.

## 201. From a list of statements concerning the proper operation of sewer mains, choose the correct statements.

**Factors Affecting Proper Operation of Sewer Mains.** There are three primary factors that affect the

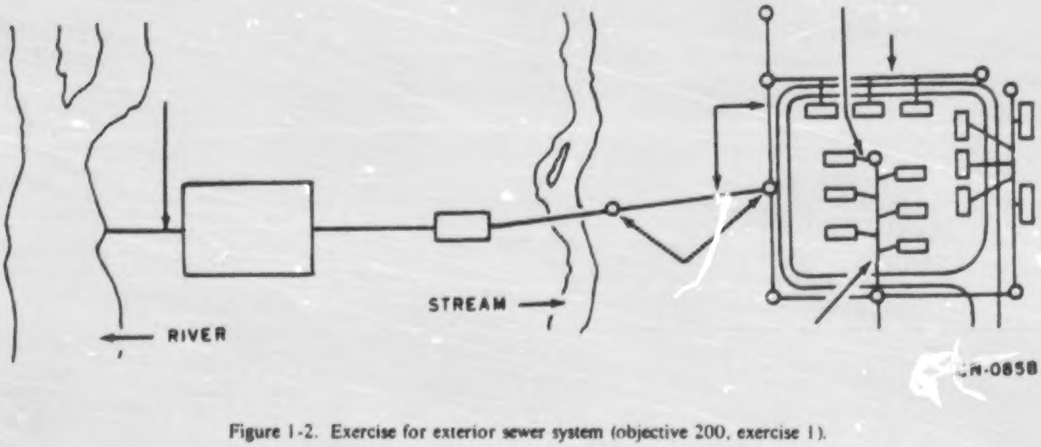

Figure 1-2. Exercise for exterior sewer system (objective 200, exercise 1).

proper operation of sewer mains: (1) correct size pipe to handle maximum flow, (2) the correct slope to insure proper flow, and (3) the lack of obstructions to provide continuous flow.

*Pipe sizing.* Sewer piping must be large enough to handle the peak, as well as normal sewage flow. If the pipe is too small, the sewage flow during peak periods will be restricted. In turn, if the pipe is too large, the waste water has a tendency to leave the solids behind, thereby creating maintenance problems. The design engineers normally compute the size of sewer mains.

*Fall per foot.* Horizontal drainage must be installed at a uniform slope. Building sewers of 3 inches in diameter must be installed with a fall of not less than 1/4 inch per foot. Building sewers larger than 3 inches in diameter will have a slope (fall) not less than 1/8 inch per foot. Laterals, submains, and main sewers will be sloped so a minimum flow rate of 2 feet per second will be maintained.

Pipe which is laid with a fall greater than 1/4 inch per foot permits the waste water to run away from the solids. On the other hand, sewers laid with too little fall slow the sewage flow sufficiently to permit solids to settle in low spots or corners. Clogging of the sewer may result in either case.

*Obstructions.* Sewer lines must be kept free from obstructions. Some obstructions which can be found in sanitary sewer systems are tree roots, jacked joints, crushed piping, sand from poor joints, excessive grease buildup, clothing articles, and excessive amounts of paper.

**Exercises (201):**

Choose the correct statements by placing an X in the spaces provided.

____ 1. The size of a sewer pipe has an effect on its operation.

____ 2. If the sewer pipe is too large the waste water runs off and leaves the solids.

____ 3. Main sewers must have a fall of at least 1 foot per second.

____ 4. Building sewers of 3 inches in diameter must have a fall of 1/4 inch per foot.

____ 5. Tree roots have no effect on the operation of sewers.

____ 6. Three things that affect the proper operation of sewers are pipe size, fall per foot, and obstructions.

**202. From a list of statements concerning construction of sewer trenches, select those that are correct.**

**Excavating.** Excavating is one of the necessary tasks with which you, as a plumber, will be confronted. Almost all exterior piping systems must be buried below the frost line.

Drainage systems are important because defective or inadequate drainage systems on a base may contaminate the potable water supply or food and cause the spread of disease. Both storm and sanitary systems are installed in trenches, so let's take a look at the work that is involved in pipe trench preparation.

Before you make any excavation, you must have a digging permit. The term "excavation" means digging or opening of an existing surface to a depth exceeding 4 inches below the existing grade. The information on the permit will help you determine what precautions are necessary to protect existing underground utilities. The permit is AF Form 103, Civil Engineer Construction Permit.

Next, study the layout of the sewer. After you study the layout, which is shown in the blueprint for the system, locate and mark the centerline of the trench in the area where the trench is to be dug. Now, decide what precautions should be taken when digging the trench. The type of soil and the depth of the trench dictate the precautions that must be followed to prevent caving of the trench walls.

In stable ground, where there is no danger of cave-ins, the trench may be dug with the walls parallel from the top to the bottom. However, if the soil is soft or wet and there is a danger from cave-ins, you must use other methods of trench excavation.

The simplest method to overcome the hazards of cave-ins is to dig the trench with steps or shelves from the bottom to the top, as shown in figure 1-3. This method removes from the sides of the trench a considerable amount of unstable dirt. Remove all rocks, boulders, and clods from the edge of the trench so that they will not roll into the trench and hit someone.

*Shoring.* The purpose of shoring is to prevent cave-ins. Cave-ins have claimed the lives of many workmen who neglected to shore the walls of the trenches in which they worked or who did not shore the trench walls properly.

Figures 1-4 and 1-5 show two views of a properly shored trench. Strong material such as 3/4-inch

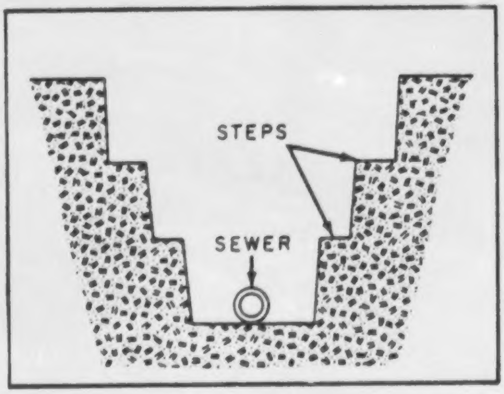

Figure 1-3. Stepping or shelving a trench.

exterior plywood or 2 x 4 planks is placed against the trench walls, forming an inner wall. Horizontally placed 2″ x 4″ lumber provides a base for shoring jacks. The shoring jacks are extended, forcing the inner wall against the trench walls. The shoring jacks, by virtue of their placement, offer some constraints for the workmen. However, their proper installation will save lives.

The sides of excavations in stable materials of 5 or more feet deep, and those in loose dirt more than 4 feet deep, should be properly and substantially braced and shored, or the sides should be sloped away from the hole. The type of shoring system to be used will be determined by soil conditions, vibrations in the area, stresses imposed by nearby buildings, and other pertinent conditions. Where excavations are to be made below adjacent foundations or pavements, these structures should be suitably braced or shored as long as the excavation is open to prevent collapsing. Dirt removed from the excavation and other materials should not be piled closer than 2 feet to the edge, and loose boulders, stumps, and other debris that could slide into the excavation should be removed from the area.

Access ladders extending above the trench sides at least 3 feet should be placed at not more than 50-foot intervals in trenches to provide safe and convenient exits from the area in case of cave-ins.

Bridges, walkways, guardrails, barricades, warning signs, and lights will be placed over or near open excavations that may present hazards to vehicle or pedestrian traffic.

Materials used for bracing, shoring, and underpinning should be kept in good condition, especially timbers, which must be sound, free from large or loose knots, and of the required dimensions. Bracing and shoring should be inspected frequently when in place, particularly after rains, and any adjustments needed must be made immediately. When horizontal cross braces cannot be used to support the sides of excavations, substantial and adequate shoring or tie rods should be used. Tie rods should be placed far back from the slope of the excavation and securely anchored. Cross braces or trench jacks should be cleated, scabbed, or securely fastened in place by some other satisfactory means.

Areas close to the sides of excavations should be well drained. Ladders or ramps should be installed for safe access to depressions more than 4 feet deep. To provide maximum personnel safety, no tools, materials, or debris should be left near the edges of excavations which could accidentally be knocked off or cause a worker to lose his footing. Pick and shovel men must be kept far enough apart when working to prevent their injuring each other.

When mechanical methods are used, the shoring should always be placed within 6 feet of the operating buckets or booms. Where hand excavating is carried to such depths that intermediate shoveling platforms are necessary, they must be built strong enough to hold substantial loads and in such a manner as to prevent material from falling back into trenches. Trench sides must not be undercut more than 6 inches without additional shoring or bracing.

*Grading.* Your ditch digging job is not completed until the trench is graded to insure that waste materials

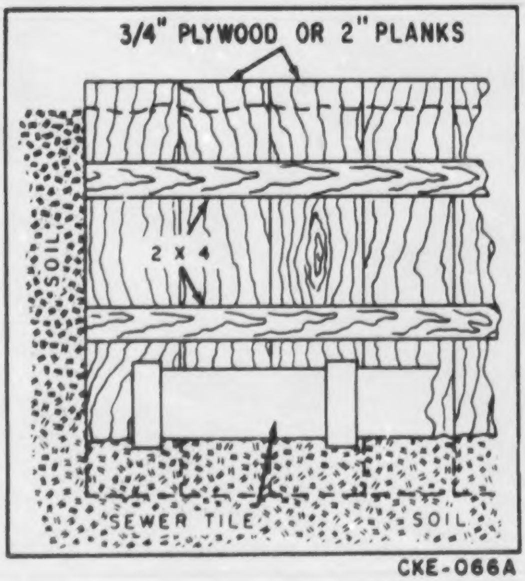

Figure 1-4. Side view of a shored trench.

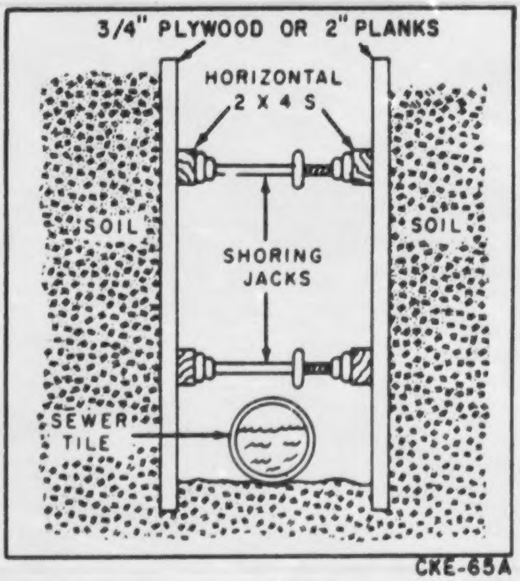

Figure 1-5. End view of a shored trench.

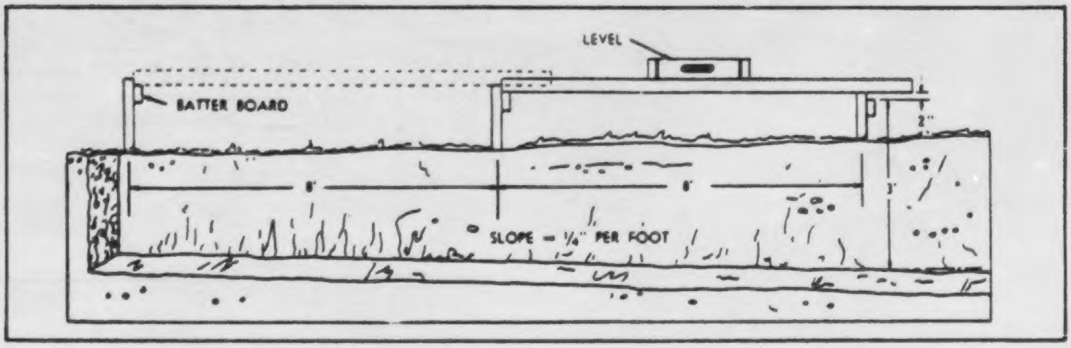

Figure 1-6. Grading a sewer trench

and surface water will flow through the pipe. The outlet of the sewer is lower than the inlet because the sewage flows through the sewer line by gravity flow. Slanting the sewer pipe in this way is referred to as the "fall." The desirable fall for a house sewer is 1/4 inch to each running foot along the line. In a properly graded trench, you can lay soil pipe without leveling each joint and thus save much time. This proper fall is insured by establishing a grade line and then digging the trench exactly to this line.

A properly graded (sloped) trench permits proper grading of sewer pipe. If too much dirt is removed and loose dirt is used to fill in, the pipe may settle and cause breakage or stoppage. Grading requires the use of an engineer's transit or batter boards.

When an engineer's transit is not available, use the batter board method, shown in figure 1-6. When using this method, drive batter board stakes into the ground at 8-foot intervals. Nail a block of wood 2 inches below the top of the batter board stakes on both sides of the trench. As each consecutive batter board is driven into the ground, place a board that is over 8 feet long on the block of the preceding batter board and on top of the second batter board. Place a carpenter's level on the top of this board and drive the second batter board into the ground until the bubble in the level is centered. The 2-inch fall over the 8-foot run established by this method gives a 1/4-inch fall per foot. Then dig the trench the complete distance, dropping down 2 inches every 8 feet of run. Always begin the trench at the point where it connects to the building drain and maintain the proper grade toward the main sewer. If the main sewer is lower than the line to be installed, place the last section or two of pipe at the required angle to make the connection to the main.

Another way of grading is done with the use of a level. The level is placed on the pipe at the high end and a block of wood, corresponding in thickness to the grade required, is placed under the low end of the level. When the air bubble shows level (in the center of the glass) the pipe has the proper grade.

The length of the level must be considered; if the level is 2 feet long and the grade is 1/4" per foot, the block under the level must be 1/2" thick, as shown in figure 1-7.

If it is not possible to place the level on the top of the pipe (such as overhead piping), the level can be placed under the pipe, as shown in figure 1-8.

*Pumping trenches.* Sometimes surface water or rainwater may enter the trench, especially when it is necessary to leave the trench open overnight. Before

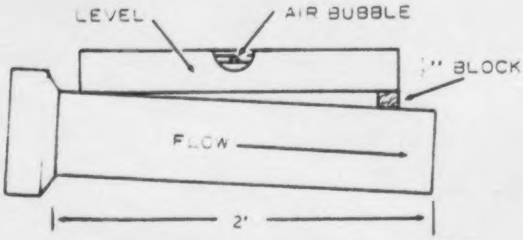

Figure 1-7. Grading with level on top of pipe.

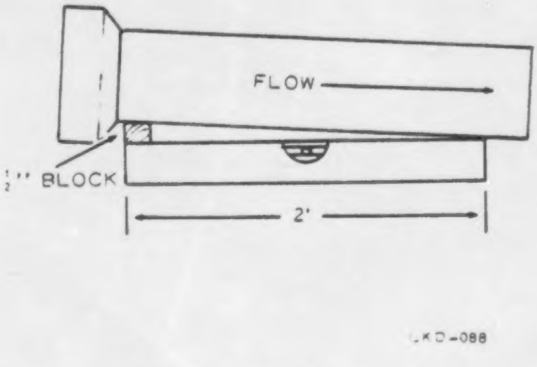

Figure 1-8. Grading with level under suspended pipe.

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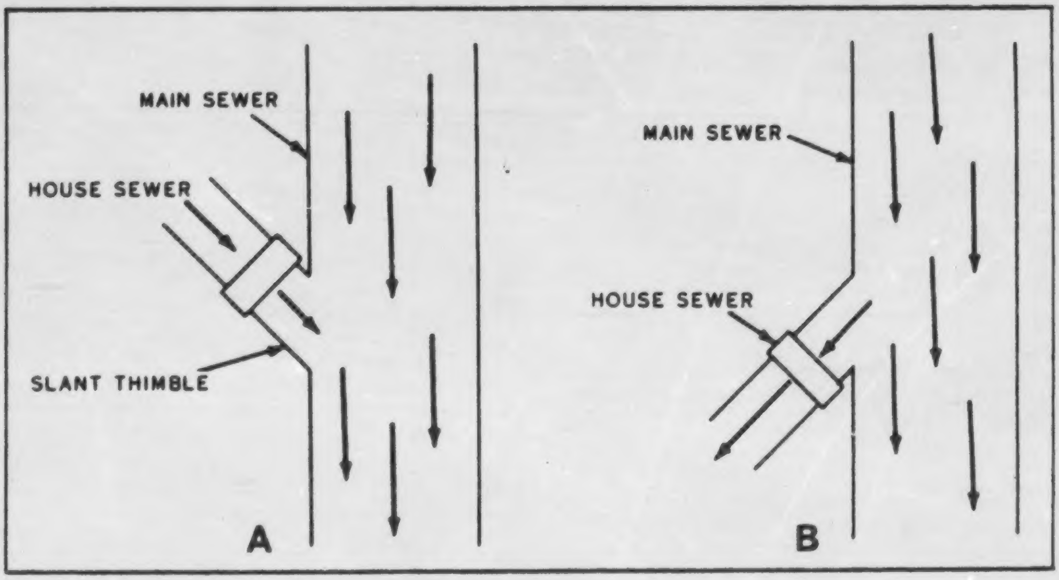

Figure 1-9. Installation of thimbles.

resuming pipe-laying operations, you must remove this water from the trench. You can do this either by bailing it out with a pail or sucking it out with a power sump pump. The pump is usually powered by a small gasoline engine, similar to the engine used to run a lawnmower.

There are several precautions you should observe when using a power pump. First, give the pump and engine a complete visual inspection for damage. Check the gasoline tank for gas leaks, and check the engine for oil leaks. Add gasoline to the tank, and add oil to the engine crankcase if necessary. Never fill the gas tank when the engine is running, as spilled gas is too easily ignited by a hot engine. Always remove the ignition wire from the spark plug before you make adjustments which will require turning the engine by hand. This will prevent accidental starting of the engine. During the operation of the engine, make sure that the blower screen, flywheel vanes, and cylinder cooling fins are kept clean to prevent overheating of the engine. See that the pump case is completely filled with water before starting the pump. It will not prime unless the pump case is full. Never operate the pump for more than 5 minutes without water running through it.

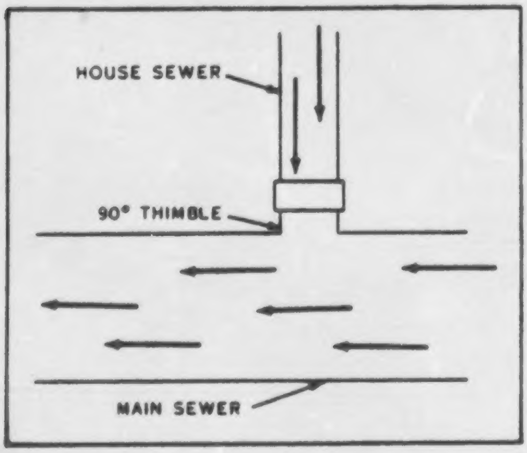

Figure 1-10. Thimble placed at 90° to main sewer.

To aid in your pumping operation, dig a slight sump in the lowest point of your trench. At this point you can insert your suction hose, thereby insuring complete drainage of the trench.

**Exercises (202):**

Select the correct statements by placing a checkmark (√) in the spaces provided.

____ 1. The first thing you should do before digging a trench is to obtain a digging permit.

____ 2. Excavations in loose dirt more than 3 feet deep should be shored.

____ 3. Safety ladders will be extended at least 3 feet above the trench and at intervals not more than 50 feet apart.

____ 4. When digging machines are used, the

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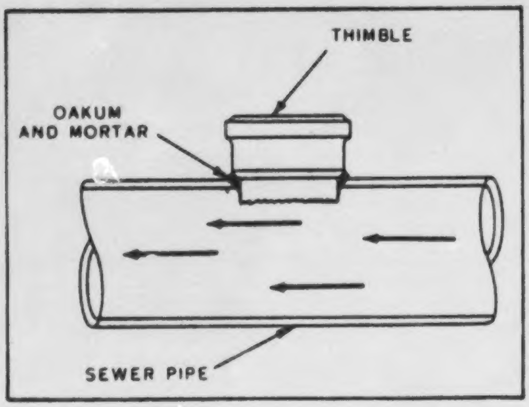


Figure 1-11. Installing thimble in sewer pipe.

shoring will always be placed within 6 feet of the bucket.

____ 5. When using the batter board method of grading, trench stakes will be placed at 4-foot intervals.

____ 6. Never fill a pump engine with gas while it is running.

____ 7. Digging a sump in the lowest point of your trench serves no purpose.

## 1-2. Installation of Building Sewers

As soon as the trench is dug and graded, your next job is to connect the house sewer to the main. Now let's find out how this connection is made.

**203. Provided a list of statements relating to the use of thimbles for connecting sewers, select the correct statements.**

**Measuring and Cutting Thimbles.** The house sewer is connected to the main sewer by a thimble, which is a short section of sewer pipe with a hub. The degree at which the thimble enters the main sewer is very important. It should be placed at an angle which will discharge the flow from the house sewer in line with the direction of the flow in the main sewer, as shown in A of figure 1-9. Never place the thimble in a direction which will produce a scooping effect, as shown in B of figure 1-9. During periods of high sewage flow in the main, such an installation would produce a backflow from the main sewer and might flood the lower levels of the building. In some cases where the house sewer is above the grade of the main sewer, a thimble placed at 90° to the main sewer (see fig. 1-10) makes a satisfactory connection.

The length of a thimble should be determined before it is installed. It should be long enough to extend through the sewer pipe wall with the hub of the thimble resting on the top of the sewer pipe, as shown in figure 1-11. This type of installation prevents the bald end of the thimble from extending into the main sewer and causing an obstruction to the flow of sewage.

Thimbles may be made of concrete or vitrified sewer tile. The method of cutting both materials is similar. Usually, you , the plumber, will select a piece of pipe (preferably a scrap piece which has a good hub) to make the thimble. After the length of the thimble has been determined, mark the pipe. It may be marked to the length desired by filing a small groove around the pipe with a three-cornered file, or by chipping a groove with a small cold chisel and ball peen hammer. To chip the groove with a cold chisel and hammer, place the pipe on top of a soft mound of dirt, as shown in figure 1-12. This procedure absorbs the shock caused by blows of the hammer, and prevents the vitrified or concrete pipe from breaking. To cut the pipe, use the chisel and hammer to chip away small pieces of pipe from the groove as you turn the pipe on the mound. Continue turning the pipe, and deepen the groove by tapping the chisel with the ball peen hammer until the pipe shows signs of cracking in the groove. It usually cracks all the way around and breaks off at once.

To cut a slant thimble, use the same procedure as in cutting a 90° thimble except for marking the line of cut. You can locate a 45° marking around the pipe by making a line with chalk around the pipe approximately 2 inches below the hub, as shown in A of figure 1-13. Measure the outside diameter of the spigot end of the pipe (4-inch sewer tile will usually

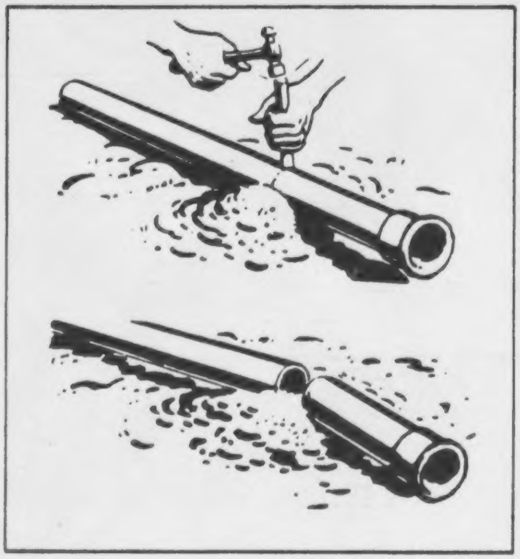


Figure 1-12. Cutting a groove in pipe with a cold chisel.

have an outside diameter of 5 inches) and make a second line around the pipe 5 inches below the first line. Next, make a third line around the pipe halfway between the other two lines, as shown in A of figure 1-13. Now, locate four points around the circumference of the pipe which are equal distances, or 90°, apart. You can locate these points by wrapping a strip of paper around the pipe and then folding it twice from end to end. Unfold the paper and wrap it around the pipe again. The four points to mark are indicated by the creased lines where the paper was folded. Draw a line along the run of the pipe through each of the four points, as shown in B of figure 1-13. You can now draw the line around the pipe by using the reference points located where the other lines cross and work toward the other end, as shown in C in figure 1-13. This completes the marking on the sewer pipe; now you can make your cut.

**Exercises (203):**

Select the correct statements by placing a C in the appropriate space.

____ 1. The degree at which the thimble enters the main sewer is not important.

____ 2. Thimbles can be made of concrete or vitrified sewer tile.

____ 3. To absorb shock when cutting concrete or vitrified sewer tile, you should place the pipe on a mound of soft dirt at the point it is to be cut.

____ 4. To cut a slanted thimble, you would use the same procedures as in cutting a 90° thimble, except for marking the line of cut.

____ 5. Sewer pipe being cut rarely ever cracks all the way around and breaks off at once.

**204. From given statements concerning installation of sewer thimbles, choose those that are true.**

**Installation Thimbles.** Proper installation of thimbles is very important. You must take care when tapping the sewer main or you will break the sewer pipe, thereby creating additional work. You must also make certain that the joints are made correctly. Poorly made joints make easy access for tree roots and sand infiltration.

*Tapping the main sewer.* After the thimble is prepared, you are ready to tap the main sewer. You should install the thimble above the normal sewage flow line. You can determine the location for the hole by tapping the main lightly with a ball peen hammer. A dull sound indicates that you are tapping below the sewage level, and a ringing sound indicates that you are tapping above the sewage level. When you have determined the position of the hole, use the thimble as a pattern for marking the line of the hole with chalk. Make the cut on this line with a small cold or cape chisel and an 8-ounce ball peen hammer, as shown in figure 1-14. Use only light blows when you make the cut, because if you damage the main sewer you will

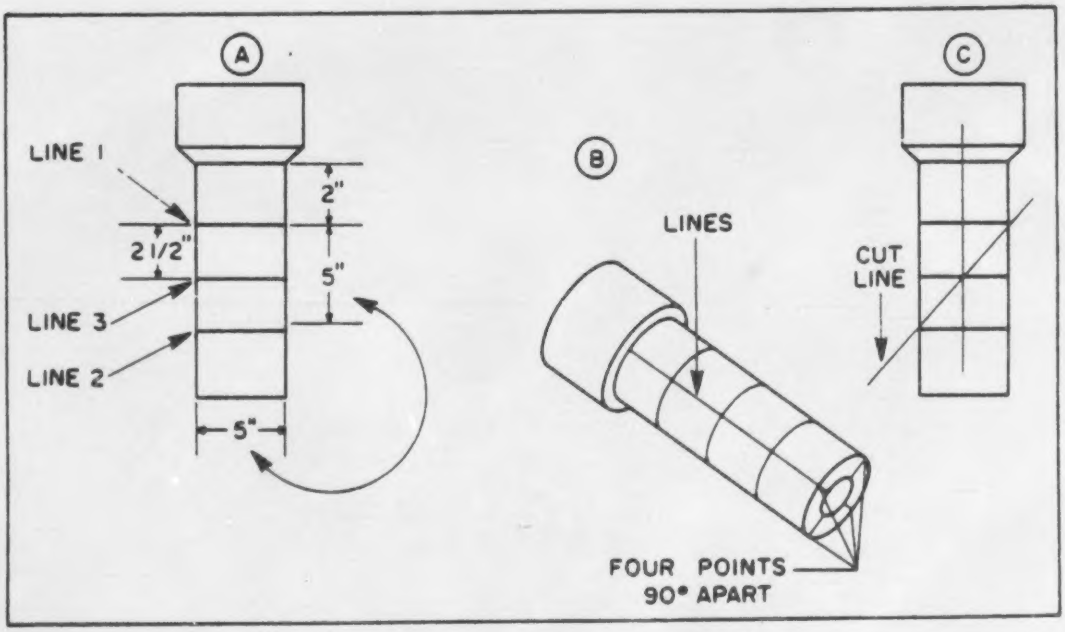


Figure 1-13. Marking a 45° thimble.

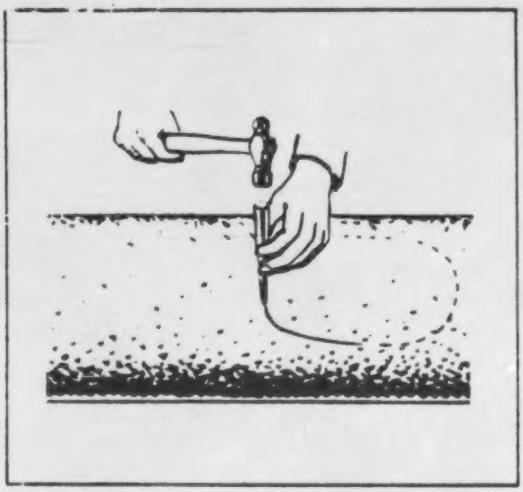


Figure 1-14. Cutting a hole in the main sewer.

have to replace one or more sections of the pipe. Continue to work around the cut until a depth of 1/8 to 3/16 inch is reached. Now, go to the center of the area to be removed and make a small hole with a chisel and hammer. Remember, always use light blows to prevent damage to the pipe. When the small hole in the sewer is chipped out, the ball end of the hammer can be used to chip out and enlarge the hole. Never use direct blows, but use glancing blows that break out small chips toward the center of the hole. As you near the edge of the area to be removed, the thimble can be used to determine when the hole is large enough. Take care to prevent the chips from falling into the main sewer. Because of their weight, they will fall to the bottom of the main and collect solids that will cause stoppage of the sewage. When you have fitted the thimble to the hole, use oakum and mortar to seal the joint. Pack a liberal amount of cement around the joint, and support the thimble until the cement hardens.

Lay the house sewer pipes in the trench beginning at the thimble of the main sewer, and work toward the house drain. If a short piece of pipe is required in the line, place it away from the thimble and nearer to the house drain. After placing the sewer pipe in the trench, remove the soil beneath each hub so that the pipe will rest firmly on the trench floor. Your next procedure is to make the joints.

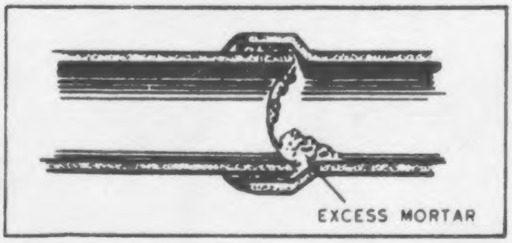


Figure 1-15. Joint made without oakum.

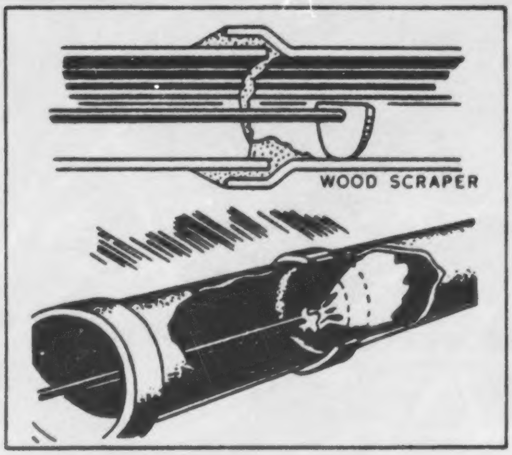


Figure 1-16. Removing excess mortar.

*Making joints.* Concrete or tile sewer line joints, used either for sanitary or storm sewers, are sealed with either oakum and mortar or oakum and hot bituminous compound. Before you make a joint, see that the spigot end of the tile is centered in the hub of the joining pipe. A joint that is not centered tends to leak on the side that has the least space. First, pack the oakum into the hub with sufficient pressure to tamp it, but do not exert too much pressure because you may break the hub of the pipe. Next, mix a sufficient amount of mortar, pack it into the bottom of the hub, and continue up the sides and over the top. Apply enough mortar to insure a watertight seal and shape it to make a neat appearing job. See the diagram of a pipe joint made without using oakum in figure 1-15. Note the buildup of mortar inside the pipe. Excess mortar within a pipe is undesirable because it restricts the flow of sewage. To remove the mortar, use either a wood scraper or a swab, as shown in figure 1-16. Remove the excess mortar as soon as you complete the particular joint. Your mortar mix should consist of one part cement to two parts sand.

The preferred method in installing vitrified pipe is to use hot bituminous compound to seal the joint. This compound is heated and then poured into the joint. Use an asbestos runner, shown in figure 1-17, to direct the hot compound into the joint. Be extremely careful when you are handling the hot compound and equipment, because if it contacts your body, you will probably be burned seriously. This type of joint is preferred over mortar because plant roots do not grow through the compound joints into the pipe as easily as they grow through mortar joints. You also use hot bituminous compound to seal the joints in vitrified pipe to cast iron pipe.

There is another way to joint vitrified clay pipe, that is with the use of manufactured seals. These seals are made of rubber or plastic. They have excellent characteristics, such as resistance to root penetration, watertight seal, and they will not rot or corrode.

**Exercises (204):**

Choose the true statements by placing a T in the space provided.

____ 1. A ringing sound indicates that you are tapping above the sewage level.

____ 2. After you have marked the hole to be cut in the main sewer, you should use a 16-oz. hammer and 1-in. cold chisel to cut the hole.

____ 3. You should use only light blows when cutting an opening in the main sewer.

____ 4. Chips falling into the main sewer, while cutting openings, will have no effect on the operation of the sewer.

____ 5. To mix mortar for pipe joints, the cement and sand ratio is one part cement to two parts sand.

____ 6. The preferred method to join vitrified pipe is to use hot bituminous compound to seal the joint.

____ 7. To join cast iron soil pipe with vitrified sewer pipe you would use oakum and lead.

____ 8. A joint that is not centered tends to leak on the side that has the least amount of space.

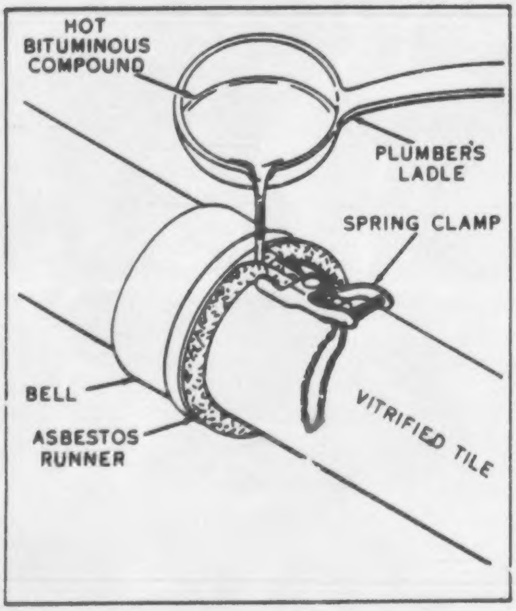


Figure 1-17. Making a joint with hot bituminous compound.

**205. Given a list of steps pertaining to backfilling trenches in random order, arrange them in their correct sequence.**

**Backfilling the Sewer Trench.** After installing and inspecting the sewer pipes, backfill the trench. Before backfilling, you should remove the rocks from the fill dirt. Normally, the natural excavated earth is satisfactory for use in backfilling trenches. You should backfill the trench as soon as the inspection is completed to avoid shifting of the pipe, which will cause damage to the joints. You should insure against lateral movement of the pipe by backfilling around the pipe and tamping to a distance of at least 1 foot above the top of the pipe. Do not permit working or walking on top of the installed pipe, except as necessary to backfill and tamp, until the trench has been backfilled to at least 2 feet above the pipe. For best results in backfilling, you should backfill in layers of not more than 6 inches and tamp with a mechanical tamper until desired compaction is obtained. When you have reached the 2-foot level of compacted backfill, you may use equipment to backfill the remainder of the trench except in traffic areas where compaction is required to ground level.

**Exercises (205):**

The following steps for backfilling trenches are in random order. Place numbers in the following lettered blanks, arranging them in their correct sequence. a. ________ b. ________ c. ________ d. ________ e. ________

*Random Order*

*Steps*

1. Backfill around the pipe and hand tamp.
2. Remove rocks from fill dirt.
3. Backfill to surface level with equipment.
4. Backfill in layers of 6 inches.
5. Tamp backfill with mechanical tamper.

### 1-3. Individual Waste System

In isolated areas where there are no sewer systems, it is necessary to install a disposal unit that can treat small quantities of waste water and sewage. Septic tanks and disposal beds will effectively take care of a limited amount of waste.

**206. Provided a list of statements pertaining to septic tanks, select the correct statements.**

**Septic Tank.** The use of septic tanks and disposal beds is the answer to sewage disposal where there are no common sewers in the area. The septic tank and disposal bed are efficient methods for disposing of single-dwelling sewage waste and water. The solids are reduced to liquids through bacterial action. Septic tanks are constructed of several types of materials, such as cinder blocks, concrete, metal, and fiberglass.

*Functions.* The tank is a means of arresting the flow of sewage so that practically all of the solid matter which it contains will settle to the bottom of the tank.

The septic tank, when properly designed, will hold the sewage long enough for bacterial action to reduce most of the solids to liquids. In liquid form, the sewage is more easily handled for further purification.

*Bacterial action.* It is generally believed that a septic tank must have chemicals in order to operate correctly. This is not true. Certain bacteria exist in fresh sewage. The septic tank simply furnishes a breeding place for these bacteria where they may be free to attack the sewage without being disturbed.

The raw sewage that enters the tank contains bacteria, minute forms of life, on which the operation of the tank depends. This sewage is composed of animal, vegetable, and mineral solids carried along with the liquid. The bacteria acts strongly on the vegetable and animal solids, but they cannot act on metal or mineral substances. These metal and mineral parts of the sewage settle to the bottom of the tank in the form of sludge, and they must be removed at intervals. If given sufficient time, the bacteria will reduce most of the animal and vegetable solids to liquid forms. Twenty-four hours is usually sufficient time for this action to take place. Even such substances as leather and bones can be reduced to liquids in time. It is essential to design the tank to provide this needed time.

The bacteria contained in the sewage thrive in the tank and multiply very fast. They begin their attack on the solids which settle to the bottom of the tank. As their action continues, gas is generated in the process; and as the gas escapes toward the top, it carries up with it particles of the solid matter, which collects at the surface of the tank and forms a thick scum. The bacteria attack this scum and breed abundantly in it, as well as on the sides of the tank. The bacteria breed best when light and air are excluded. The crust prevents light from entering the liquid. The highest concentrations of bacteria are found on the underside of the scum layer. Therefore, it is very important that the scum of the septic tank be left as undisturbed as possible. For this reason, the inlet and outlet must be arranged to prevent materials entering or leaving the tank from disturbing the scum layer.

The bacteria that break the solids down to liquids are called anaerobic bacteria. These bacteria do not purify the sewage, but only liquify the solids. When a potato decays, it first becomes soft and then turns to a liquid form. This is accomplished without outward change. This action is similar to the liquifying process that takes place in the septic tank. The idea that sewage liquid is purified to any degree while in the tank is not true. The solid parts of the sewage are simply reduced to liquid form, and this action prepares the sewage for the final purification process. The final purification of liquid sewage takes place in various types of disposal beds.

*Construction of septic tank.* The secret of constructing a septic tank that will give satisfactory service is to select a design that provides a means of holding the bacteria scum in the tank in an undisturbed state. Septic tanks may be built with one or more compartments; but single compartment tanks, provided they are large enough to accomodate the volume of sewage, operate as efficiently as the others and are less expensive to construct. A septic tank that is simple in design and effective in operation is illustrated in figure 1-18. The siphon chamber is not absolutely necessary for the operation of the septic tank for individual disposal systems, but the installation of a siphon chamber insures a positive flow of liquid from the chamber, and the chamber should be used in multiple unit disposal systems. The baffle boards are usually made of 2-inch oak planks and run entirely across the tank. They are suspended from hangers and set to extend several inches below the surface of the sewage. One board should be located 10 inches from the inlet end of the tank and the other about 4 inches from the outlet partition. Baffle boards reduce the agitation of the layer of scum on the surface of the tank by slowing the water currents through the tank, which are caused by the splashing of solids from the inlet.

Sewage should enter the tank at a low velocity in order to prevent it from agitating the scum in the tank. To produce a slow flow, the drain to the septic tank should run nearly level before reaching the tank. The inlet should enter the tank above the sewage level and

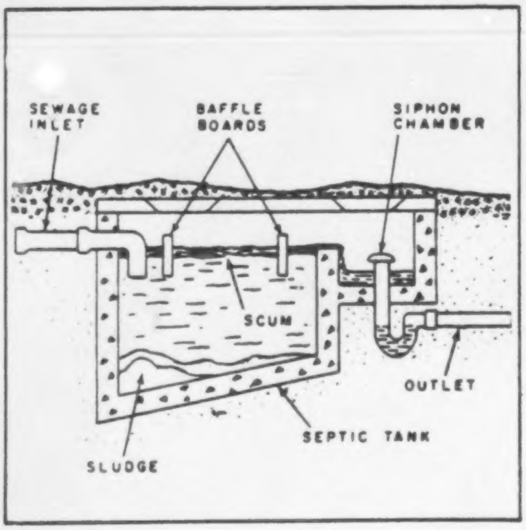


Figure 1-18. Diagram of septic tank.

turn down in order to direct the solid matter toward the bottom of the tank, and also to prevent agitation and consequent breaking up of the scum which accumulates at the surface. The partition between the two chambers in the tank should be perfectly level, so that sewage will flow over it evenly along its entire length.

The bell siphon, located in the siphon chamber (see fig. 1-18) operates on a principle similar to placing a bottle, neck first, into a pail of water. As you push the bottle neck further below the surface, no water can enter the bottle, because the air is trapped inside.

A bell siphon is constructed with a long leg trap and a bell-shaped cover. Figure 1-19 shows the progressive steps in the operation of a bell siphon. Notice how the rising water level in the discharge chamber traps air between the bell cover and the water seal in the trap. As the weight of the rising water compresses the air, the water seal in the trap is forced over the short leg of the trap and the air escapes. The weight then forces water to enter the bell and trap and flow out of the chamber. The velocity of the water sets up a siphoning action, which continues the drainage flow until the water level falls below the lower rim of the bell and allows air to reenter the bell cover. The trap is resealed by the last portion of the drainage flow, and the siphon is set for another cycle of operation when the water rises in the discharge chamber. The trap must be installed before the floor in the discharge chamber is constructed. The bell cover may be installed after the floor and walls are completed.

The bottom of the septic tank should pitch downward toward the inlet end. It is here that the heaviest part of the sewage is naturally deposited when entering the tank. Cleaning of the tank is thereby made easier. Both the tank and the siphon chamber should be provided with a manhole and cover to give access for cleaning and repair purposes.

Practically all of the sewage entering the tank is acted upon by bacteria and liquified. Only a small amount of sludge remains, as compared to the volume of sewage entering the tank. The accumulation of sludge is slow, and the time between cleanings of the septic tank is estimated to be from 1 to 5 years. The sludge should not be allowed to accumulate to a depth greater than one-fourth of the total depth of the tank.

Figure 1-20 illustrates two other methods of constructing septic tanks using sanitary tee's in place of baffle boards. If your original septic tank is not large enough to handle the sewage, you may add an additional chamber, as illustrated in view B of figure 1-20. The additional chamber may be installed on either side of the existing tank.

**Exercises (206):**

Select the correct statements by placing a C in the space provided.

___ 1. Septic tanks are constructed of metal, concrete, fiberglass and cinder blocks.

___ 2. A properly designed septic tank will hold the sewage long enough for bacterial action to reduce most solids to liquid.

___ 3. Septic tanks must have chemicals to operate correctly.

___ 4. Sewage liquid is purified while in the septic tank.

___ 5. Septic tanks may be built with one or more compartments.

___ 6. Septic tanks should be provided with a manhole for cleaning.

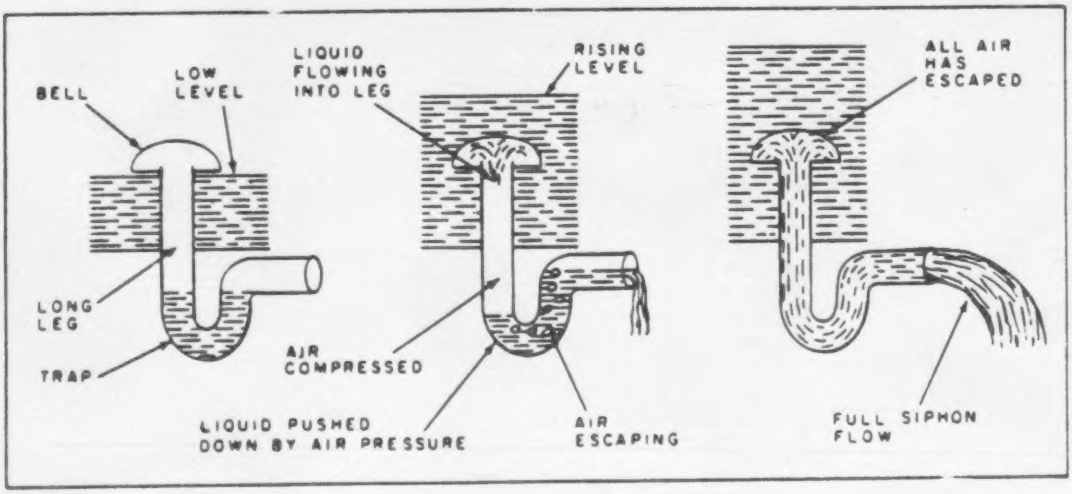


Figure 1-19. Progressive steps in the operation of the discharge bell siphon.

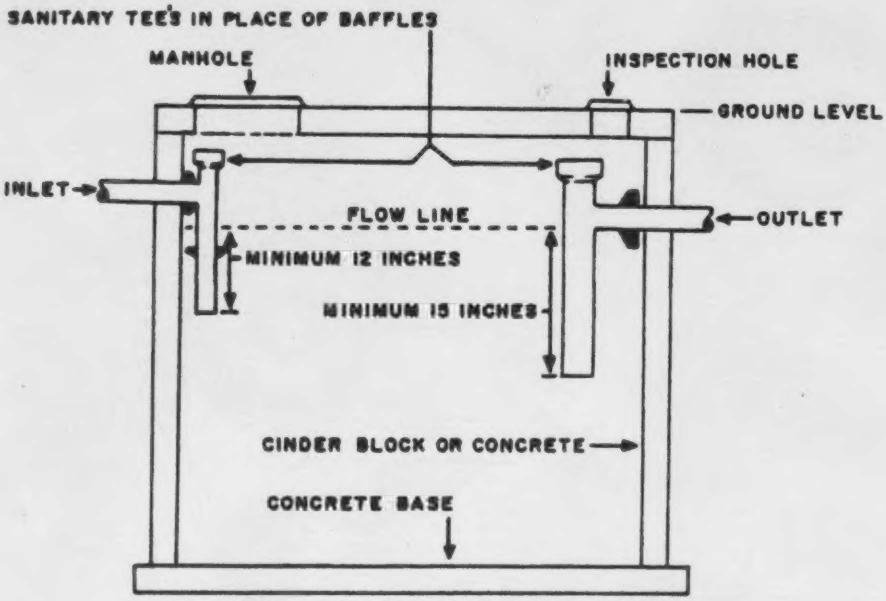
____ 7. Sludge should not be allowed to accumulate more than one-fourth of the total depth of the tank.

____ 8. Sanitary tees should not be used in place of baffle boards.

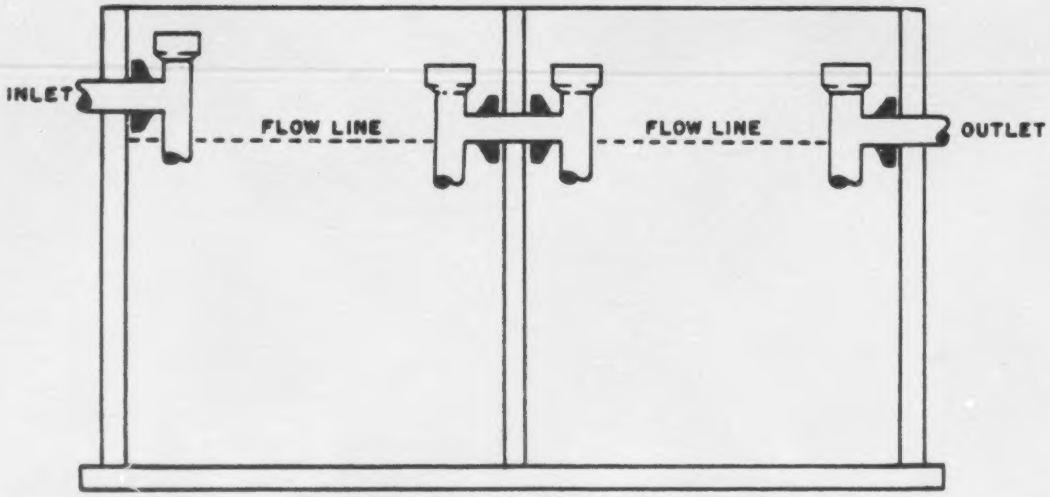
**207. From given information concerning sewage disposal beds, choose the true statements.**

**Sewage Disposal Bed.** The septic tank merely prepares the sewage for final purification by reducing the solid parts to liquid form. The sewage must be purified elsewhere.

Final purification of sewage liquid takes place either in dry wells, disposal beds, or fields. The terms "leaching area," "absorption field," and "subsurface


SANITARY TEE'S IN PLACE OF BAFFLES
MANHOLE
INSPECTION HOLE
GROUND LEVEL
INLET
OUTLET
FLOW LINE
MINIMUM 12 INCHES
MINIMUM 15 INCHES
CINDER BLOCK OR CONCRETE
CONCRETE BASE

A. SINGLE COMPARTMENT SEPTIC TANK


INLET
FLOW LINE
FLOW LINE
OUTLET

B. DOUBLE COMPARTMENT SEPTIC TANK

C-NF-027

Figure 1-20. Septic tanks without siphon chamber.

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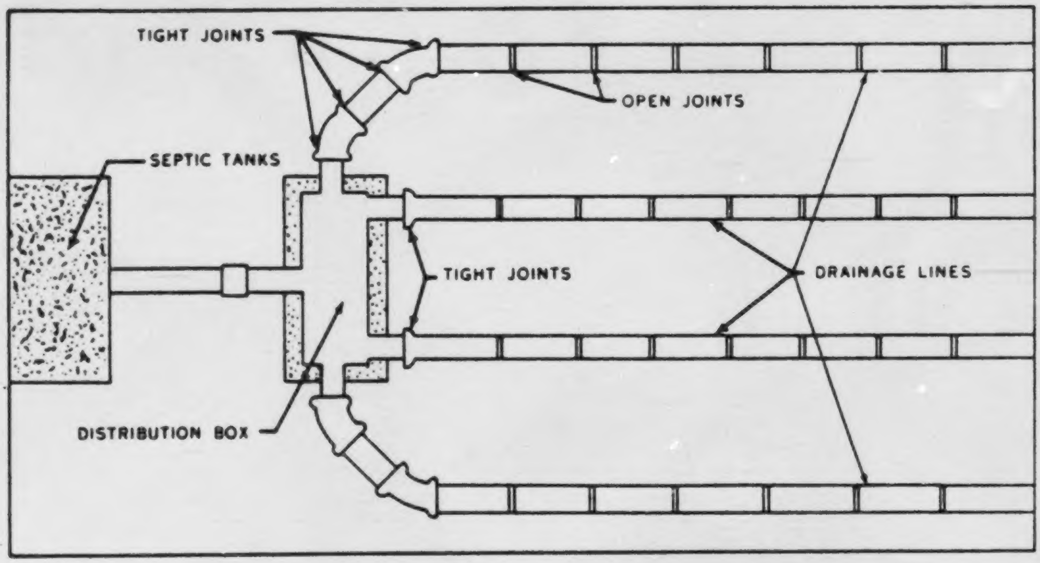
TIGHT JOINTS
OPEN JOINTS
SEPTIC TANKS
TIGHT JOINTS
DRAINAGE LINES
DISTRIBUTION BOX

Figure 1-21. Typical disposal bed.

tile system" are commonly used to refer to a disposal bed of some type.

A disposal bed, shown in figure 1-21, consists of a network of pipelines constructed with open joint. Perforated pipes and tiles such as concrete tile, vitrified clay tile, asbestos cement pipe, plastic pipe, or fiber pipe may be used in disposal beds. This type of construction allows the soil to absorb the sewage liquid along the entire length of the lines. The liquid is uniformly distributed to the lines of the disposal bed through a distribution box that is connected directly to the septic tank.

*Bacterial action.* Bacterial action takes place in disposal beds near the surface of the ground. These bacteria, unlike those in the septic tank, need oxygen to survive. The bacteria are concentrated near the surface because the oxygen decreases with depth. There are more bacteria in light, sandy soils than in tight, heavy, soils, because oxygen penetrates the light soils in greater amounts. Disposal fields that are deeper than 5 feet generally do not have sufficient bacterial action to render the liquids harmless. For this reason, disposal field pipes should be installed as close to the surface of the ground as possible.

The distribution box insures equal flow to all lines of the disposal field from the septic tank. This gives the disposal bed a longer life.

*Construction of drainage bed.* You must consider several factors when constructing a drainage bed for a septic tank. You must know the general lay of the land, the depth of the potable water supply, the location of lakes or surface streams, and the type of soil. The

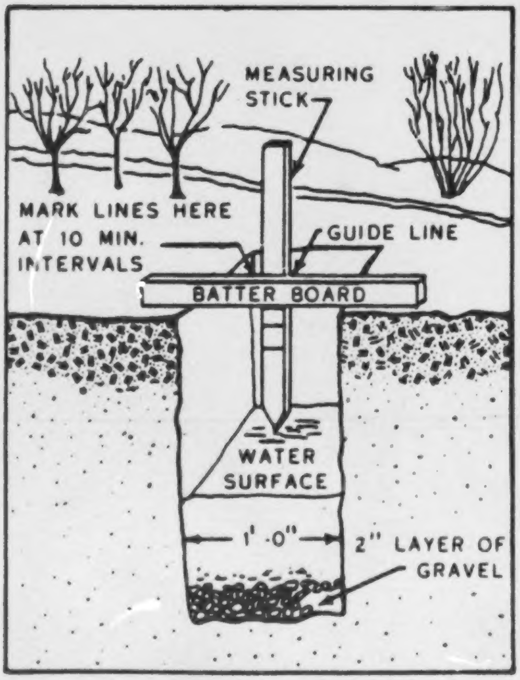
MEASURING STICK
MARK LINES HERE AT 10 MIN. INTERVALS
GUIDE LINE
BATTER BOARD
WATER SURFACE
1'-0"
2" LAYER OF GRAVEL

Figure 1-22. Percolation test of soil.

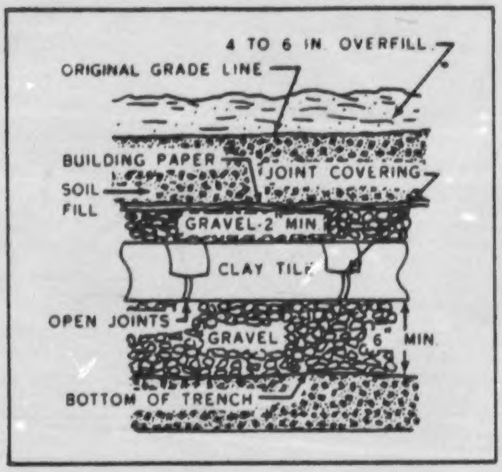

Figure 1-23. Installation of open joint clay tile.

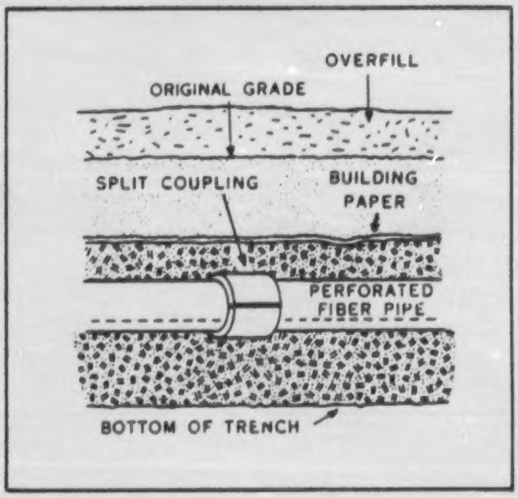

Figure 1-24. Installation of perforated fiber pipe.

subsurface tile system is the most common drainage bed construction. It is used whenever space and soil type permit or when there is no stream or pond nearby. The length of piping necessary to handle the volume of liquids in a subsurface drainage bed is dependent upon the type of soil and the volume of liquid to be purified.

You should make a percolation test of the soil to determine the length of the drainage lines. To make this test, dig a hole 12 inches square to a depth equal to that of the planned drainage bed. Place a 2-inch layer of gravel in the bottom of the hole and fill it with water. If the soil is tight or contains a heavy clay content, allow the test hole to stand overnight for a soaking period. If the soil is sandy and the water disappears very rapidly, no soaking period is necessary, and you can continue the test. Refill the test hole with water to a level of 6 inches above the gravel, as shown in figure 1-22. Place a batter board across the top of the hole for a reference line and use a ruler to record the level of the water in the hole below the batter board. Continue to measure the water level at 10-minute intervals over a 30-minute period. The drop in water level during the final 10-minute interval is used to determine the percolation rate of the soil. A soil type which absorbs up to 1 inch of water in 10 minutes or less requires 18 inches of drainage per gallon of liquid. Soil which requires 30 minutes to absorb 1 inch of water, is not considered to be satisfactory for a subsurface drainage system. You should use at least six test holes over the drainage bed area and determine an average percolation rate when figuring the length of the drainage lines.

You should consider the general slope of the land when laying out the drainage field, and dig the trench with a fall of 2 to 6 inches per 100-foot run. A trench should be 18 to 24 inches wide and at least 18 inches deep. Additional depth may be necessary to adjust to the contour of the land or to give room for 6 inches of gravel under the line. Several short lines are preferred over a single long line, because if damage occurred to any one line, most of the field would still be serviceable. A system which requires approximately 100 feet of drainage line should be laid out with either three 35-foot lines or four 25-foot lines. Space these trenches from 6 to 10 feet apart. Be sure to place a layer of loose gravel in the bottom of the trench before laying the pipe.

The drainage lines may be constructed of either tile or perforated pipe. If clay tile is used, you should aline the sections in the trench with 1/4- to 1/2-inch gaps at each joint. Place a strip of heavy building paper over each joint, as shown in figure 1-23, to prevent trench fill from entering the pipe.

When using perforated fiber pipe to construct drainage beds, make the joints with standard split

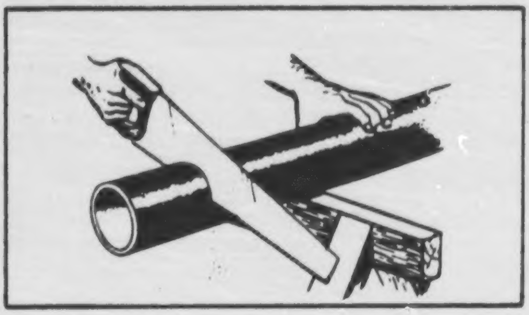

Figure 1-25. Cutting perforated pipe.

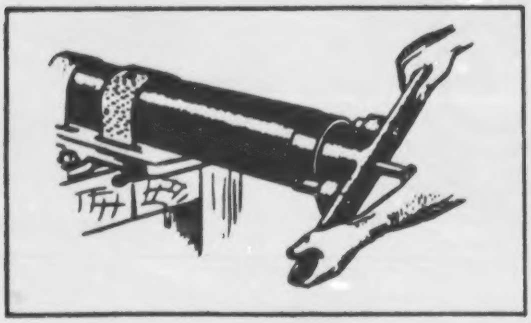

Figure 1-26. Cutting a taper on fiber pipe.

couplings as recommended by the manufacturer. Place the pipe in the trench with the perforations facing downward, as shown in figure 1-24.

Fiber pipe is used, when it is available, because it is easily cut, fitted, and installed. You can cut it to any length with a common handsaw, as shown in figure 1-25. A drop of oil on the cut will prevent gumming and binding of the saw blade.

By using a tapering tool on the cut end, you can make a new taper for a joint, as shown in figure 1-26. Be sure to read and understand the operating instructions before you use the tapering tool. You must aline the tool on the pipe perfectly to make a cut which is centered and has a uniform wall thickness.

By using a hammer and a board to drive the coupling up to the joint, you can easily assemble fiber pipe. The board should be wide enough to cover the end of the pipe. This prevents the hammer blows from damaging the pipe. Figure 1-27 illustrates the proper way to use a hammer when you are assembling fiber pipe with connectors and fittings.

When a distribution box is used, the box should be constructed so that the exit lines from the box to the distribution lines are level. This insures a uniform flow of liquid into each line. The inlet line to the box from the septic tank should be constructed with tight joints and nonperforated pipe to prevent waterlogging of the soil around the tank.

If a distribution box is not used, you should construct a manifold or header of nonperforated pipe and fittings, as shown in figure 1-28. A single discharge main from the septic tank directs the liquid flow into the header for distribution to the drainage lines.

After the piping is installed in the trench, place gravel around and over the pipe to a depth at least 2 inches over the pipe. Then place a layer of building paper on top of the gravel and fill the remainder of the trench with soil. The building paper prevents the soil from settling into the gravel. The trench should be overfilled with 4 to 6 inches of soil to allow for settling and to drain rainwater away from the trench. Sometimes fiber pipe is connected to cast-iron pipe with mortar. Cement-asbestos pipe is laid in the same manner as other pipe, but a special coupling is required to connect it together. We discuss this coupling in another volume.

Whenever limitations of space prevent the use of a drainage bed, you may use a percolating filter dry well for disposition of the liquid waste from a septic tank. This method works satisfactorily in soil which has a high sand or gravel content with good drainage characteristics. The dry well is built of brick or stone without mortar and with an earth bottom. The well should be about 10 feet deep and not less than 4 feet in diameter. You can determine the approximate size by allowing 1 square foot of wall surface for every 5 gallons of liquid received each day. At least two stacks of inverted Y-fittings should be built into the well, as shown in figure 1-29, to insure proper air circulation.

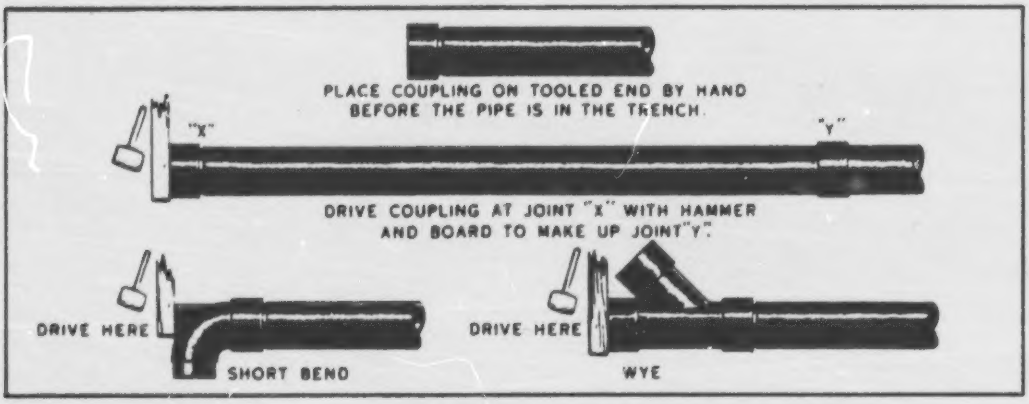
PLACE COUPLING ON TOOLED END BY HAND
BEFORE THE PIPE IS IN THE TRENCH.
"X"
"Y"
DRIVE COUPLING AT JOINT "X" WITH HAMMER
AND BOARD TO MAKE UP JOINT "Y".
DRIVE HERE
SHORT BEND
DRIVE HERE
WYE

Figure 1-27. Making fiber pipe joints.

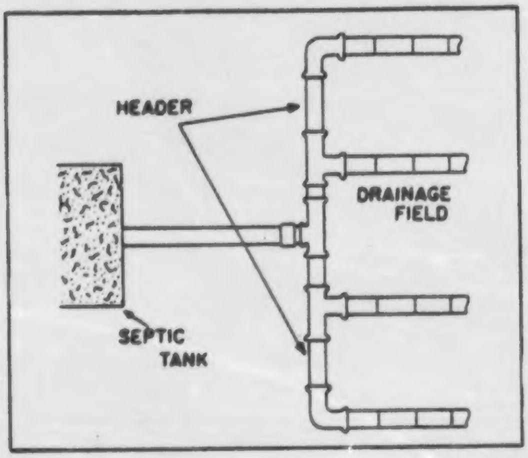
HEADER
DRAINAGE FIELD
SEPTIC TANK

Figure 1-28. Drainage bed header.

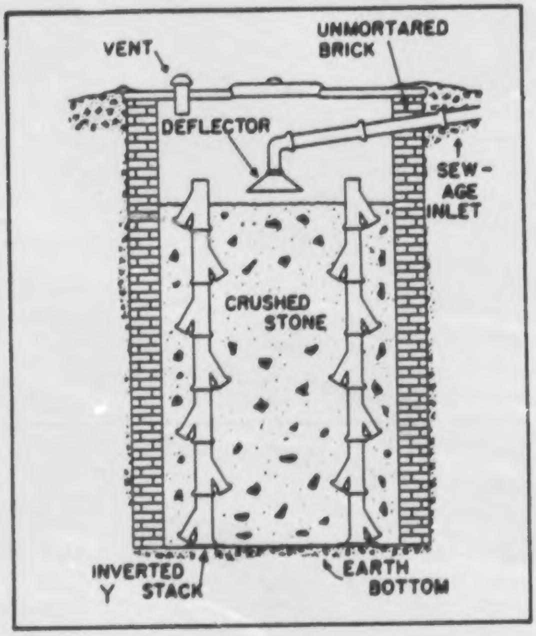
VENT
UNMORTARED BRICK
DEFLECTOR
SEW-AGE INLET
CRUSHED STONE
INVERTED Y STACK
EARTH BOTTOM

Figure 1-29. Percolating filter dry well.

The entire well is then filled with crushed rock or broken brick to a level approximately 1 foot below the inlet from the septic tank. The stacks extend above the top of the fill material to permit air to enter and aid the bacterial action in the well. The inlet should extend to the center of the well and discharge through a deflector which evenly distributes the liquid onto the filtering material. The well should have a large vent, because an adequate supply of air is essential for the operation of the filter. The dry well filter should not be used when there is danger of contamination to an underground water supply.

Whenever a stream or lake is nearby, an underdrain filter bed, like the one shown in figure 1-30, may be used to purify the liquid from a septic tank before it is dumped into a lake or stream. A filter bed is constructed by digging a basin with sloping sides into the ground. The basin should have a depth of at least 5 feet, and the sides should slope to direct the liquid to a central collection area in the bottom of the pit. An underdrain line is constructed at the bottom of the

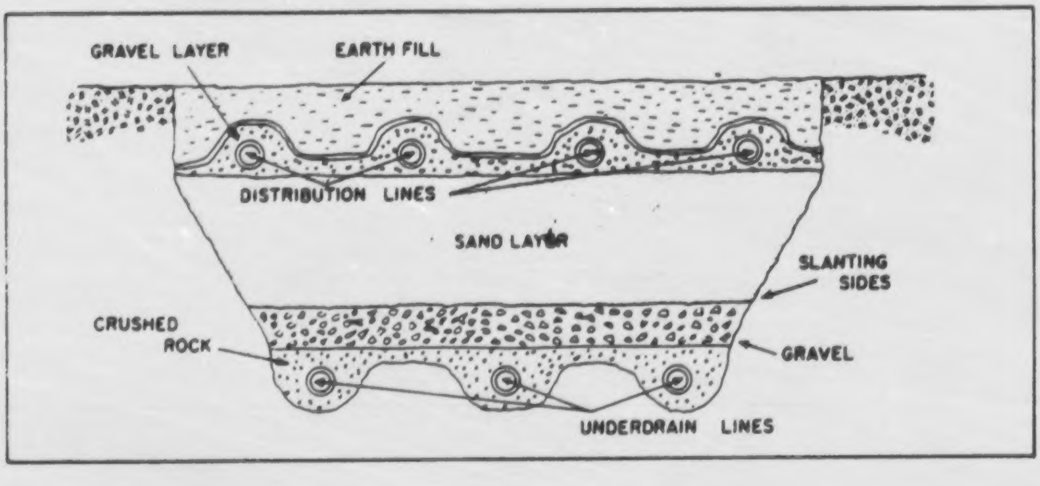
GRAVEL LAYER
EARTH FILL
DISTRIBUTION LINES
SAND LAYER
SLANTING SIDES
CRUSHED ROCK
GRAVEL
UNDERDRAIN LINES

Figure 1-30. Underdrain filter bed.

basin of open joint clay tile and connected to a drain line to the stream or lake.

This underdrain is covered with a layer of broken stone to a depth of 4 inches. An 8-inch layer of gravel is placed over the broken stone. A bed of pure sand approximately 4 feet in depth is placed on top of the gravel, and the top surface of the sand is leveled. A distributor is built over the sand so that all parts of the bed will receive equal amounts of the sewage liquid from the septic tank. You can make a temporary and inexpensive distributor of planks with a main trough running through the center of the bed and branch troughs to other parts of the bed. In areas where odors cannot be tolerated or where a permanent type distributor is desired, you should construct a subsurface open-joint tile distribution system on top of the sand layer and cover it with a gravel and earth fill. As the liquid seeps down through the sand, it comes in contact with bacteria. This bacteria purifies the liquid before it enters the underdrain pipe. The underdrain pipe conducts the liquid into a stream or lake.

You should use a discharge siphon in the discharge chamber of the septic tank any time you use a dry well or a filter field for the disposition of liquid waste. The siphon discharges the waste at intermittent intervals and allows the anaerobic bacteria in the tank time to act on the organic matter in the liquid. Two filter fields may be used with an alternating flow of liquid to each distributor. This system gives the bacteria a greater time to work and allows the filtering material in the field enough time to drain and air between discharges from the siphon.

**Exercises (207):**

Choose the true statements concerning sewage disposal beds by placing a T in the appropriate spaces.

____ 1. Perforated pipes and tiles, such as concrete, vitrified clay, asbestos cement, plastic, and fiber can be used in disposal beds.

____ 2. Bacteria in disposal beds does not need oxygen to survive.

____ 3. The distribution box insures equal flow to all of the lines in the disposal field.

____ 4. You must make a percolation test of the soil to determine the length of the drainage bed lines.

____ 5. You should use at least six test holes over the drainage bed area to determine the average percolation rate.

____ 6. A drainage bed requiring 100 feet of line serves best if the pipe is laid in one straight line.

____ 7. Six inches of gravel should be placed under the drainage lines.

____ 8. Dry wells should have at least one stack of inverted Y-fittings.

____ 9. A deflector is used in dry wells to hold the liquid for dosing.

____ 10. You should use a discharge siphon in the discharge chamber of the septic tank when a dry well is used for the disposition of liquid waste.

CHAPTER 2

# Structural Openings, Building Drains, Stacks, and Vents

WHEN PLUMBING systems are installed, openings must be cut through various parts of the structure in buildings regardless of the type of construction. On some jobs, the plumber will have to install some parts of the system, such as the building drain, soil pipes, and stack base, before the floor is installed. The rough-in supply lines for fixtures and the waste and vent piping are usually installed after the wall and roof construction are started. On most installations the plumber cannot set and connect the fixtures until the finished wall is completely installed. The rough-in plumbing is concealed by the finished wall; therefore, it is very important that the supply and drainage openings be properly located for installing the fixtures because changes will involve considerable expense and loss of manhours.

The drainage system of a building is that portion of the sewer system which carries away water and waste material which pass through the fixtures in the building, such as sinks, lavatories, urinals, showers, bathtubs, and water closets. In general, the drainage system of a building consists of a building drain, the stack, and the various fixture vents and fixture drains. The drainage system must be adequate, and it must be properly designed so that it can handle the wastes without difficulty. It is of prime importance that the system be completely leakproof and gastight, because sewer gases are deadly poisonous. This is important also to prevent odors from being dissipated into the building.

This chapter explains how to prepare openings in the different types of materials used in building construction and how to reinforce openings. It also covers building drains, stacks and vents, and ventilating waste lines.

## 2-1 Cutting Structural Openings

All buildings, regardless of the type of construction, will require that openings be cut through various parts of the structure when the plumbing system is being installed. On some jobs, the plumber may have the opportunity to install such parts of the system as the building drain, soil pipes, and stack base before the floor is installed. The rough-in supply lines for fixtures and the waste and vent piping may be installed after the wall and roof construction has been started. On most installations the plumber cannot locate and connect the fixtures until the finished wall has been installed. As the rough-in plumbing is concealed by the finished wall, it is very important that all supply and drainage openings be properly located for installing the fixtures as any changes would involve excessive expense and loss of man-hours.

**208. List the types of construction used for wooden buildings.**

**Building Construction Principles.** Most buildings are constructed of wood, masonry products, or metal; and many buildings use these materials in some part of the structure.

Either a box type or frame type construction is used for wood buildings. The box type of construction uses only a single-board thickness in the walls and has only enough framework to support the floor and roof. This type of construction is exposed because of the single-board thickness of the walls.

The frame type of construction is used for wooden buildings of a more permanent nature. This type of structure has a framework of wall studs, which are usually made of 2 x 4 or 2 x 6 lumber and then covered on both sides to form a double wall. The floor joists and ceiling joists are used to support the floors and ceilings, and the rafters are used to support the roof decking. Figure 2-1 shows the frame type of construction for a house.

The supply system and drainage piping that are located above the floor level are usually concealed within the framework to give a clean and neat appearance.

Most structures that are to be permanent are built with some type of masonry construction. They may be built of concrete, or they may use a veneer covering of brick, building blocks, or stone over a wooden framework. Concrete buildings have exposed piping for supply lines; pressure lines are never placed in concrete because of the possibility of internal leakage. Parts of the drainage system may be covered by concrete floors, but cleanout plugs must be installed at certain points to insure access to the system for

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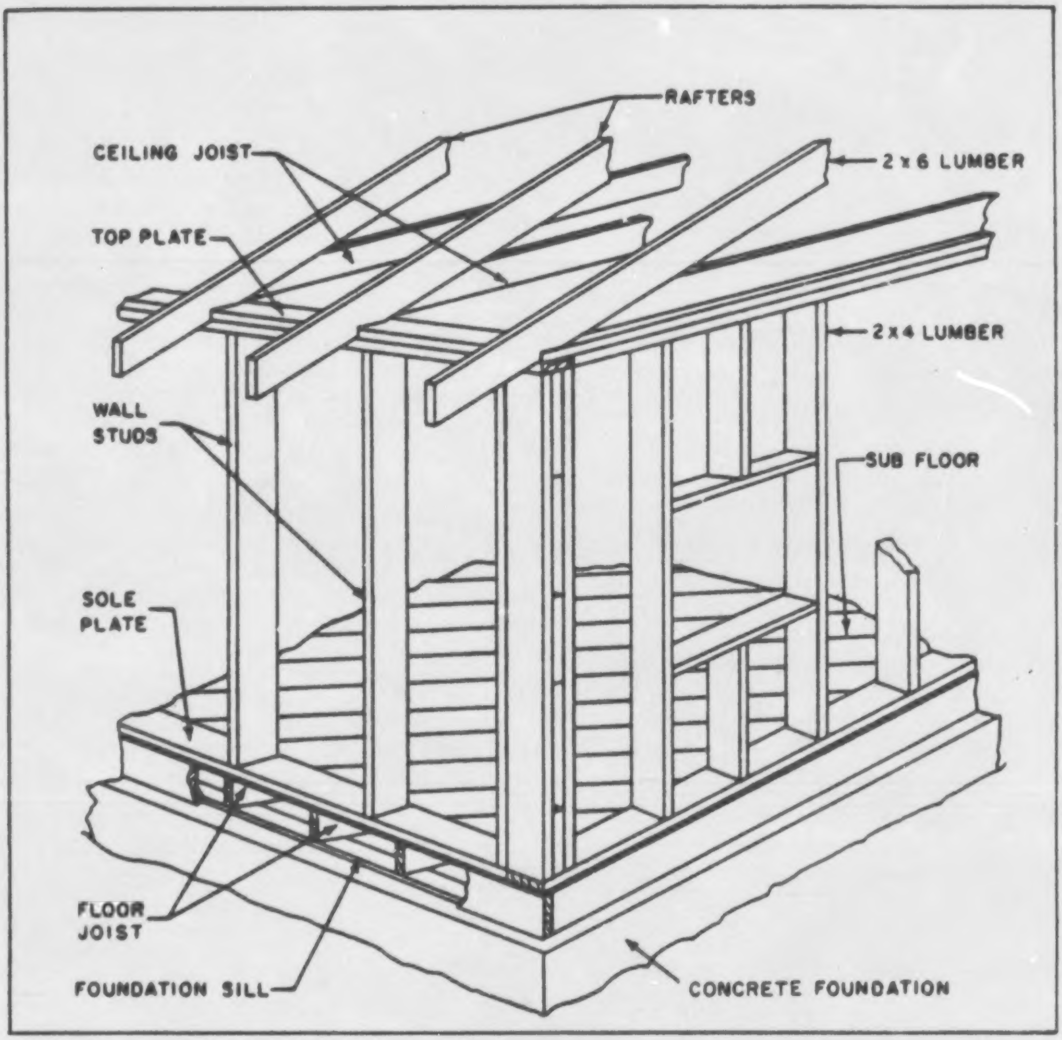
RAFTERS
CEILING JOIST
2 x 6 LUMBER
TOP PLATE
2 x 4 LUMBER
WALL STUDS
SUB FLOOR
SOLE PLATE
FLOOR JOIST
FOUNDATION SILL
CONCRETE FOUNDATION

Figure 2-1. Frame type house construction.

maintenance. The wall plumbing is installed in a veneer type of structure in much the same ways as in a wooden frame structure, because the plumbing can be concealed in the framework.

Many fireproof buildings which are to be used for storage or workshops are made of metal construction. A framework of structural steel or pipe is built and covered with sheet metal. Most plumbing in this type of structure is exposed, because the inside walls are not usually sealed.

**Exercises (208):**

Answer the following questions relating to building construction.

1. What are the three types of materials commonly used to construct buildings?

2. What are the two types of construction used to erect wooden buildings?

3. What type of construction would you use in wooden buildings that are to be permanent?

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4. With what types of materials are most permanent buildings built?

5. Fireproof buildings that are used for storage and workshops are usually constructed of what type material?

**209. Provided a list of statements pertaining to the location of openings, select the correct statements.**

**Determining the Location of Openings.** The location of the fixtures in a building must be known before pipe is installed, because most piping is installed to serve a fixture. The plumber gets this information from the building or plumbing blueprints. The exact model or type of fixture to be used is indicated on the specification sheets. The rough-in dimensions for a particular fixture are specified by the manufacturer. The plumber must use the dimensions for locating the structural openings for the waste and supply piping. After the plumber checks over the blueprints and specification sheets, he should indicate the location of the fixtures and the routing of the supply and waste pipes within the structure. He should examine the construction of the building or inspect the plans to determine the difficulties that are likely to be encountered in installing the pipes. He should notice the spacing and direction in which the floor beams run, among other details. It may be necessary, in some cases, to indicate on the work drawing the location of the floor beams or other structural members.

Using dimensions from the manufacturer's rough-in specifications, most plumbers locate the exact positions of the openings for the fixtures first. After the openings are cut in the structure, the routing of pipe to reach these openings is determined, and the openings through the other structural members are cut to accommodate the pipes. Whenever holes are bored with a brace and bit through a line of wall studs to install a water supply pipe, the holes should be centered in the studs. This minimizes the possibility of weakening the structural members and damaging the pipe with nails and screws. Many copper water lines have been punctured by nails and screws when wallboard or sheet rock has been nailed or screwed to the studs.

**Exercises (209):**

Select from the following statements those that are correct by placing a C in the spaces provided.

___ 1. You must know the location of fixtures in a building before you can determine the openings for pipes.

___ 2. The rough-in dimensions for a particular fixture are specified by the manufacturer.

___ 3. Engineers prepare a plumbing work drawing.

___ 4. When a line of holes is bored in studs to receive pipes, the holes should be centered in the studs.

**210. From given information covering cautions in cutting structural openings, choose the true statements.**

**Caution in Cutting Openings.** The type of material used for construction governs the actual cutting of the openings. You should have some knowledge of the strength of the structural beams which must be cut, and you should seek advice from qualified engineering personnel any time it appears that the strength of the structure would be jeopardized. For example, in a small residence the greatest floor load in the house would be in the bath and kitchen areas because of the weight of the fixtures and appliances to be installed in these rooms. Undercutting of the floor joist could result in sagging floors, cracking and falling of the plaster, and, in extreme cases, possible collapse of the floor. Whenever openings are cut through masonry foundation walls or through wooden floors, especially for routing pipes up and into side partitions, the holes should be made to fit the pipe as closely as possible to prevent rodents and insects from entering the building through them.

**Exercises (210):**

Choose the true statements by placing a T in the appropriate spaces.

___ 1. You should consult qualified engineering personnel any time it appears that the strength of a structure may be jeopardized.

___ 2. The type of material used for construction governs the actual cutting of openings.

___ 3. Openings should be cut at least one size larger than the pipe.

___ 4. Undercutting of the floor joist could result in sagging floors.

**211. Given a list of situations and tools used to cut openings in wooden structures, match the correct tool to the situation.**

**Cutting Holes in Wooden Structures.** You should use carpenter handtools for cutting openings in wooden frame construction. Tools, such as braces, auger bits, expansion bits, keyhole saws, sabre saws, portable reciprocating saws, electric drill motors, and arbor hole saws, may be used to cut openings in wooden structures.

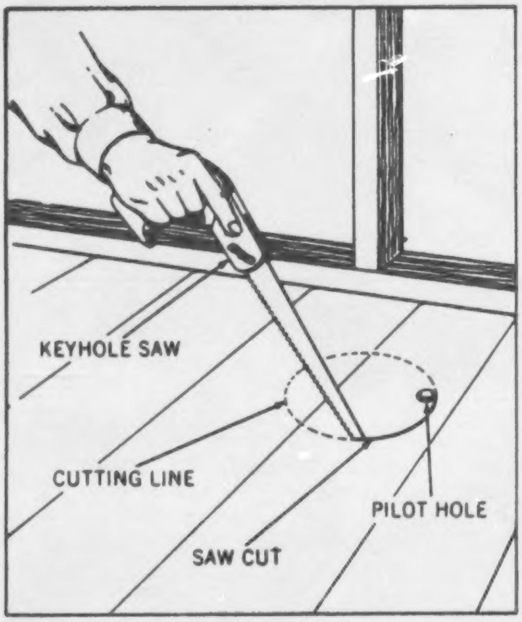

Figure 2-2. Making an opening with a keyhole saw.

A brace and auger bit, expansion bit, or electric drill motor and arbor hole saw will cut a clean hole for the installation of supply pipes. These bits and saws are available in a variety of sizes to accommodate your needs. By using an expansion bit or arbor hole saw, you can make openings for small drains and waste lines. You can make still larger openings for larger pipes, such as soil pipe, soil pipe branches, and vent pipes, by using keyhole saws, sabre saws, or reciprocating saws. The type of saw you will use will depend on the room you have to work. In close areas you may have to use a keyhole saw. First, mark a pencil or soap stone line representing the desired opening; then drill a pilot hole on the line with a brace and bit or drill motor and bit. You then start the cut with the keyhole saw at the pilot hole, as illustrated in figure 2-2. You would use the same procedures for starting your cut if you were using a sabre saw or reciprocating saw. Always be careful not to cut your power cord or any electrical lines when cutting openings.

When power tools are not available, you can make a rough opening through thick structural members, such as sole plates or floor joists, by boring a series of holes with brace and bit on the line marked for the opening. Then you can cut the material between the holes with a keyhole saw or carpenter's wood chisel, as shown in figure 2-3. When using this method, you should bore the holes as close together as possible on the portion which runs across the grain to prevent splintering when the material is cut between the holes.

To make square openings, bore holes at each corner and use a keyhole saw to saw across the grain between the holes. You can make the cut with the grain between the holes with a wood chisel.

**Exercises (211):**

Match the tool(s) in column A to the situations in column B by placing the letter(s) in the spaces provided.

*Column A*

a. Brace and expansion bit.
b. Sabre saw.
c. Arbor hole saw.
d. Reciprocating saw.
e. Keyhole saw.
f. Brace and bit.
g. Drill motor and bit.
h. Wood chisel.

*Column B*

1. __________. Cut drain and waste pipe opening.
2. __________. Cut openings, large drains, waste pipe, and vents.
3. __________. Cut rough openings through structural members when power tools are not available.

**212. From a given list of statements and tools used to cut openings in masonry structures, match the tool(s) to the statements.**

**Cutting Holes in Masonry Structures.** Openings for plumbing in masonry construction are usually more difficult to make than in wooden structures, and they should be planned and formed, if possible, when

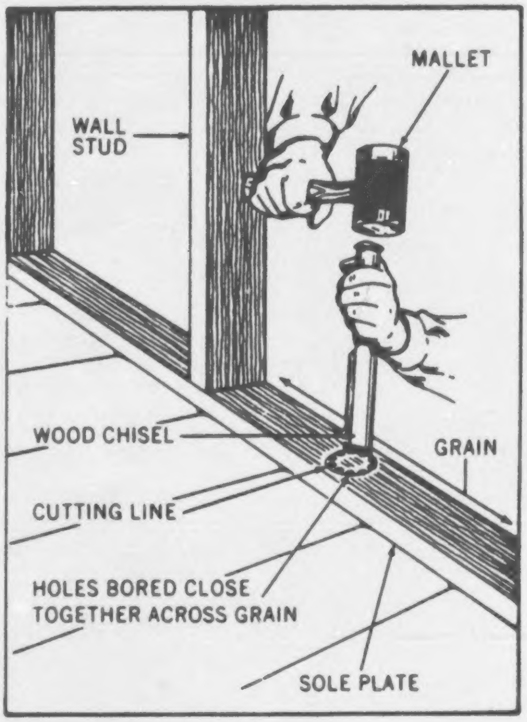

Figure 2-3. Using a wood chisel to cut an opening.

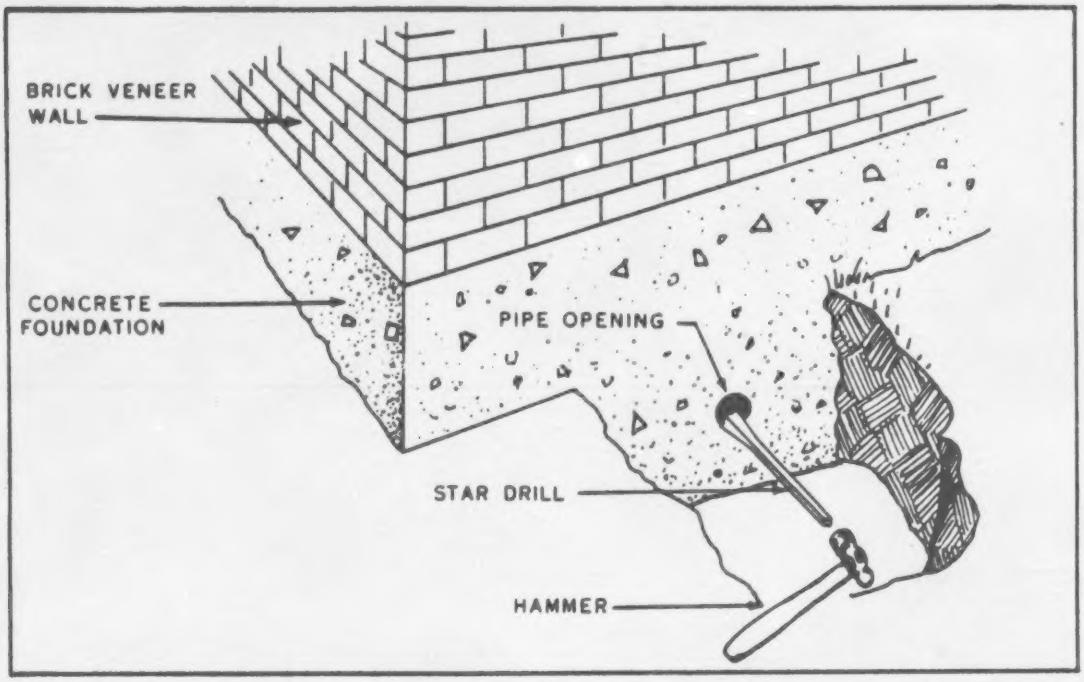

Figure 2-4. Drilling a hole in masonry with a star drill.

the concrete is poured. However, you can cut openings for pipe in solid masonry or veneer structures when necessary. If power tools are not available, you may use star drills to cut openings up to $2^1/_2$ inches. The star drill has four cutting edges and is available in diameters from $^1/_4$ to $2^1/_2$ inches and in lengths up to 24 inches. To make a cut, hold the pointed end of the drill in position on the surface to be drilled and strike the shank with a ball peen hammer, as shown in figure 2-4. During the drilling operation, rotate the drill one-eighth of a turn between hammer blows to insure faster cutting action and an even and circular hole. The drilling progress depends upon the sharpness of the drill, the hardness of the masonry, and the impact caused by the blows of the hammer.

Steel twist bits, for drilling holes in masonry construction, are also available for use with hand braces and power drills. Figure 2-5 illustrates a bit used with a power drill. The hand-operated masonry drill works well for mortar joints in brick and stone veneer construction. You must use either the power or hand-operated drill bit when making an opening through a wall that is constructed of masonry building blocks. These blocks have hollow centers, and the striking of a star drill with a hammer may break out a large section of the block to the extent that it would need replacement. If you need several holes cut, you should have a job order sent to the masonry shop.

**Exercises (212):**

Match the tool(s) in column A to the situations in column B by placing the number(s) in the spaces provided. Two or more numbers are required for each blank.

| *Column A* | *Column B* |
|---|---|
| 1. Power drill. | a. _________. Cut holes in masonry structures using handtools. |
| 2. Ball peen hammer. | |
| 3. Twist bits. | |
| 4. Star drill. | b. _________. Cut holes in masonry structures using power equipment. |
| 5. Hand brace. | |

**213. Given a list of situations concerning cutting openings in metal structures, check the correct statements.**

**Cutting Holes in Metal Structures.** The preparation of openings in metal buildings is probably the most dangerous of any type of construction because of the danger of cutting your hands on the sharp edges of the metal. Most of the jobs that require the cutting of openings in metal involve either corrugated aluminum, galvanized iron siding, or thin steel panels, which are used in partition walls. Straight line or semicircular cuts are made in these materials with a sharp cold chisel and hammer. Take care to

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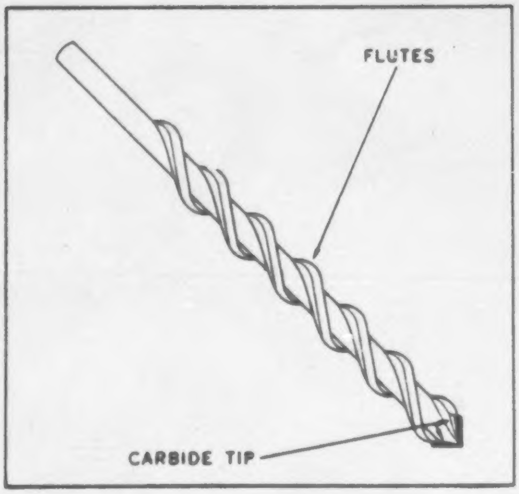


Figure 2-5. Masonry drill bit.

center the cutting edge of the chisel on the material after each hammer blow to prevent the chisel from slipping and possibly injuring your hand. You may also make cuts by using the cold chisel to make a small opening and then continuing the cut with metal shears. To cut small circular openings for pipes, make a pilot hole with a nail or small drill bit, and use the tapered end of a center punch to enlarge the hole to the desired size. As the center punch is forced into the smaller hole, the metal rolls under and burr results. Remove the edge of the burr with a half-round file in order to make a neat, round hole.

Openings in heavy steel plates or structural members are either sawed, drilled with a power drill, or cut with a cutting torch and tip.

Structural members in a metal building should never be cut or altered without prior approval of engineering personnel. Minimum sizes of structural steel that will safely support the structure are normally used during construction because of the weight problems. Therefore, if you cut the structural members, you may materially weaken the building.

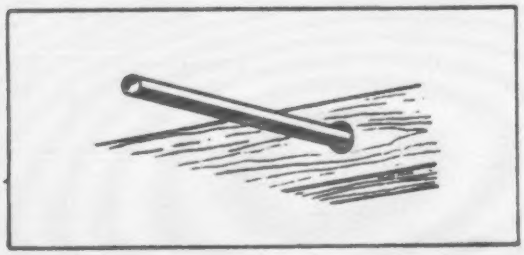


Figure 2-6. Drilled opening in the center of a beam.

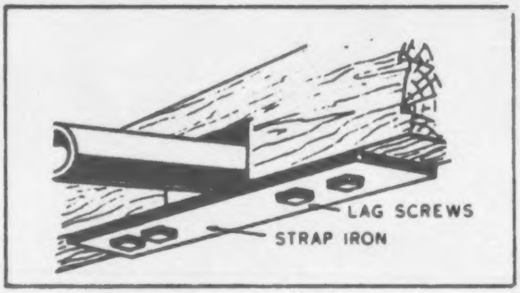


Figure 2-7. Reinforcing a beam that is undercut.

**Exercises (213):**

Check the correct statements by placing a checkmark (√) in the appropriate spaces.

____ 1. Straight line cuts in steel panels are made with cold chisels and hammers.

____ 2. To make small circular openings for pipes in iron sidings, make a pilot hole and enlarge the hole with a tapered punch.

____ 3. There is no need to consult engineering personnel when cutting openings in structural members.

____ 4. Openings in steel plates may be cut with a cutting torch.

**214. Provided a list of situations concerning the reinforcing of openings, select the correct situations.**

**Reinforcing Openings.** Since the structural members of buildings are weakened when openings for pipes and fixtures are installed by the plumber, it is important for you to learn when and how to reinforce these openings.

The plumber should reinforce the building structure when openings are cut in its members for plumbing equipment any time he thinks that the wooden type of construction needs additional wall studs, floor joists, or applicable bracing. Some fixtures, such as wall-hung lavatories or kitchen sinks,

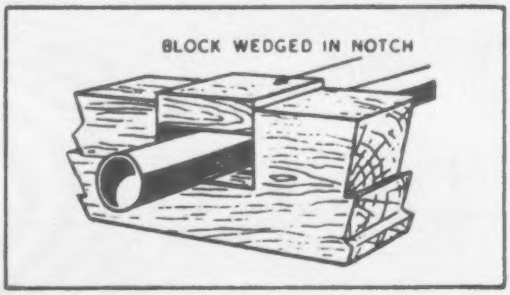


Figure 2-8. Reinforcing a beam that is overcut.

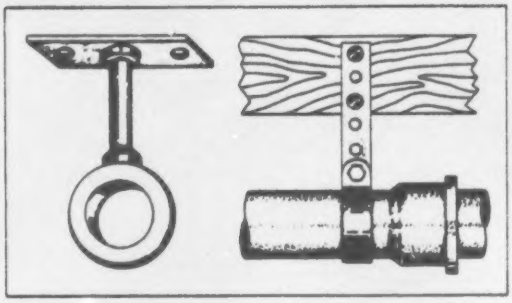


Figure 2-9. Hanger supports.

need mounting boards, and they must be built into the studding and braced before the finished wall is installed by the carpenter. Structural beams are reinforced whenever they are cut for installing pipe. Figure 2-6 illustrates a pipe opening that has been cut through the center of a beam. This cut does not materially weaken the strength of the beam unless the diameter of the opening exceeds one-third of the distance across the beam. This type of opening is generally considered to cause less damage to the structural member than do other types of cuts.

Openings for larger pipes in structural beams are usually undercut or overcut. Figures 2-7 and 2-8 illustrate the accepted methods for reinforcing beams when they are cut in this manner. When a beam is undercut, you should place across the notch a strap iron brace that is fastened with lag screws, as shown in figure 2-7. This prevents the beam from sagging when weight is applied to it. A method used to reinforce a beam that is overcut is shown in figure 2-8. As you can see, a block of wood is wedged and nailed into the notch to prevent the beam from sagging.

Structural members should be reinforced when there is doubt about the strength of a member after openings for pipe are cut.

**Exercises (214):**

Select the correct situations concerning reinforcing openings by placing a C in the spaces provided.

____ 1. A beam that has a hole cut in the center is not weakened unless the opening exceeds one-third the distance across the beam.

____ 2. Plumbers do not have to reinforce structural openings.

____ 3. Undercut beams should be reinforced with an iron strap and leg screws.

____ 4. Overcut beams can be supported with plumber's putty.

____ 5. You should reinforce structural openings when there is doubt after openings are cut.

## 215. Select the correct methods of alining, supporting, and hanging pipe.

**Alining, Supporting, and Hanging Plumbing Lines.** Plumbing lines must be alined carefully. If the fittings and joints are cocked, they tend to create stoppage and affect the efficiency of the lines. The plumbing lines must be checked periodically for shifting. Some of the things that cause hanger alinements to shift are settling of the structure, shifting of the soil, and, in some cases, pressure through the lines. A carpenter's level can be used to check the pipe alinement. Plumbing lines require support at close

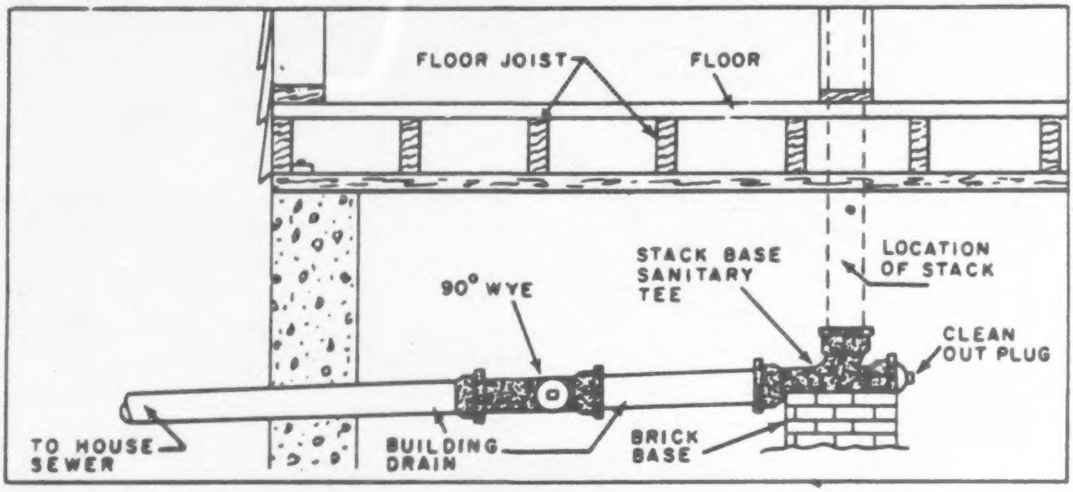


Figure 2-10. Building drain and stacks.

intervals to prevent sagging, which usually results in breakage.

Horizontal cast-iron runs of piping must be suspended by means of substantial iron ring hangers, as shown in figure 2-9. These hangers are placed approximately 5 feet apart. It is advisable to locate the support as close to the calked joint as possible. Vertical cast-iron soil pipe should be supported at its base and at each floor level.

Galvanized steel or wrought-iron pipe lines can be suspended for 12-foot intervals. They are more durable than cast iron and, therefore, require less support. These pipes should be supported and hung with supports and hangers of like materials.

Vertical copper tubing 1½ inches in diameter and smaller should be supported at 4-foot intervals; larger copper tubing should be supported at each floor level. Horizontal copper tubing up to 1½ inches in diameter should be supported at least every 6 feet; copper piping larger than 1½ inches in diameter will be supported at intervals not to exceed 10 feet.

There are no established standards on supporting plastic pipe and tubing. However, some manufacturers recommend that plastic pipe and tubing should be supported every 24 to 36 inches, and that plastic straps should be used for support. Runs of piping installed between wooden joists or steel joists must be supported on substantial wood or pipe headers that are spiked or otherwise fastened solidly to the building framework.

**Exercises (215):**

Select the correct methods of alining supporting and hanging pipe by placing an X in the spaces provided.

____ 1. Horizontal cast-iron soil pipe should be supported with hangers approximately 5 feet apart.
____ 2. Hangers should be located as close to the calked joints as possible.
____ 3. Vertical soil pipe should be supported at every joint.
____ 4. Galvanized steel can be suspended at 12-foot intervals.
____ 5. Horizontal copper tubing 1½ inches and less in diameter should be supported a maximum distance of at least 6 feet.

## 2-2. Building Waste Systems

Now that you have learned how to prepare and reinforce openings in the structural members of buildings for installing pipe and fixtures for plumbing systems, you are ready to learn how to install a plumbing system. Let's start with the building drain.

### 216. Given a list of statements pertaining to building drains, mark the correct statements.

**Building Drains.** The building drain is that part of the system under the building, shown in figure 2-10, which receives the discharge from the soil and waste stacks and carries it to the building sewer. You must plan carefully when laying out the building drain and locating the fittings for the soil and waste pipes, which are made of cast iron, copper, or plastic.

The building drain usually begins at a point of connection with a soil or waste stack and continues to a point at least 3 feet outside the building foundation for tie-in to the house sewer, as illustrated in figure 2-10. The drain is located below the floor and may be partially underground or suspended from the basement ceiling. The upper end of the drain is usually attached to a combination wye and 1/8 bend which rests on a brick or concrete base in constructions without basements. In constructions with basements, the combination wye and 1/8 bend and building drain are anchored rigidly to the floor joists. The combination wye and 1/8 bend is usually equipped with a cleanout plug and acts as a base for the stack. The stack is the vertical pipe which directs the sewage flow from above to the drain. The number of stacks required and their exact locations are determined by the location of the fixtures.

**Exercises (216):**

Mark the correct statements by placing a checkmark (√) in the appropriate spaces.

____ 1. The building drain begins at the soil and waste stack and continues to a point at least 3 feet outside the foundation.
____ 2. The building drain is always covered with dirt.
____ 3. Building drains and stacks are connected by means of a combination wye and 1/8 bend.
____ 4. The stack base is usually equipped with a cleanout plug.

| FIXTURE | FIXTURE UNIT VALUES |
|---|---|
| Water Closet | 6 |
| Urinal | 5 |
| Lavatory | 1 |
| Kitchen Sink | 2 |
| Slop Sink | 3 |
| Floor Drain | 1 |
| Shower | 2 |
| Laundry Tub | 2 |

Figure 2-11. Fixture table

| Diameter of Pipe | Fall of Pipe Per Foot in Inches | | |
|---|---|---|---|
| (Inches) | 1/8 | 1/4 | 1/2 |
| 2 | | 21 | 26 |
| 2 1/2 | | 24 | 31 |
| 3 | | 27 | 36 |
| 4 | 180 | 216 | 250 |
| 5 | 390 | 480 | 575 |
| 6 | 700 | 840 | 1,000 |

Figure 2-12. Capacities of piping in fixture units.

**217. State factors to consider when sizing building drains.**

**Sizing the Building Drain.** Building drains must be large enough to carry off all the water and waste materials that may be discharged into them at any one time. To select the proper sized building drain, you must first calculate the maximum discharge of water and waste materials into it. This is done by calculating the total individual fixture unit values discharged into it from the various branches through the stack and waste system.

The fixture unit corresponds to 7½ gallons or 1 cubic foot of water that an ordinary lavatory would discharge into the stack in an interval of 1 minute. All other fixtures commonly used in plumbing installations have been tested for maximum flow, and the fixture unit values have been established for each, as shown in the fixture table in figure 2-11.

Suppose you want to know the maximum size of a building drain for a plumbing system that has two water closets, two lavatories, a slop sink, a kitchen sink, a pair of laundry tubs, two floor drains, and a shower. First, determine the number of fixture units in the installation by multiplying the total number of each type of fixture by the fixture unit values, as shown in figure 2-11. Total the fixture unit values; in this case it is 27. Then, to determine the diameter of the soil pipe to be used for the building drain, refer to figure 2-12. Continuing with the above example, which has a total fixture unit value of 27 units, and assuming a fall of 1/4 inch per foot, we find that it would take a pipe 3 inches in diameter for the building drain.

**Exercises (217):**

1. What is the first step in selecting the proper size pipe for building drains?

2. How much water will an ordinary lavatory discharge into a stack in a 1-minute interval?

3. What is the total fixture unit value for 2 water closets, 3 lavatories, and 2 showers?

**218. Distinguish between accurate and inaccurate statements concerning installation of building drains.**

**Installation of the Building Drain.** After you have determined the location of the building drain and the stack, you are ready to make the installation. The fitting, which serves as a stack base on which the stack is constructed, must be positioned and installed when the building drain is fabricated. Figure 2-10 illustrated how a sanitary tee is used as a stack base. Notice the cleanout plug, which is installed in the tee for future maintenance of the system. The 90° wye in the building drain was installed, in this case, to connect a 4-inch waste pipe to serve the kitchen area of the building. The blocking under the stack base is necessary to position the fitting under the floor opening for the stack and to prevent the stack base from settling when the weight of the stack is added. The building drain is positioned to grade, and the fall should not exceed 1/4 inch per foot of run. After the location of the fittings in the drain is determined, the measurement for the pipe run between the fittings can be determined. The measurements between the fittings must be made between the center of the fittings.

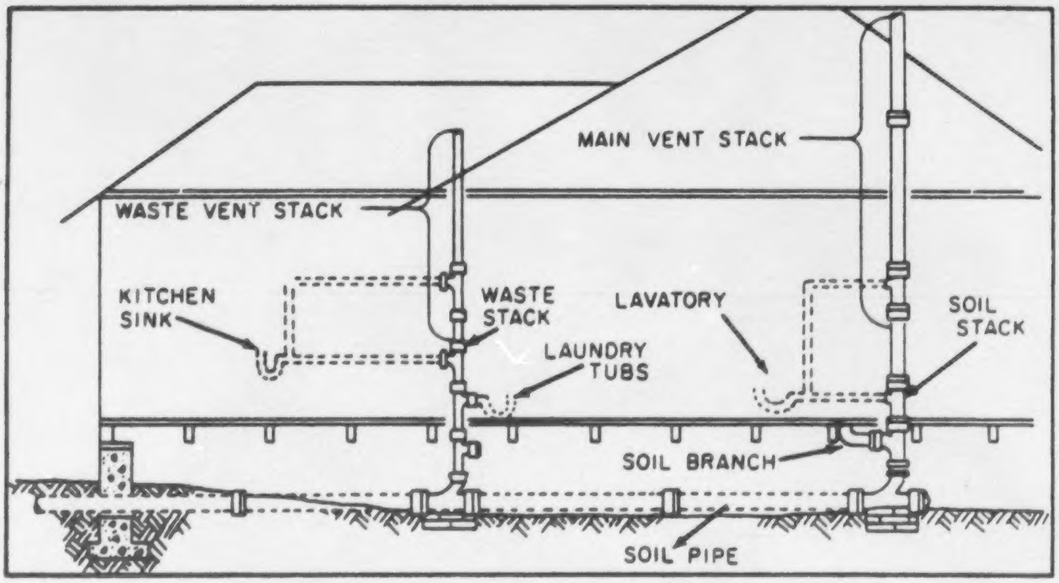


Figure 2-13. Identification of stacks.

**Exercises (218):**

Mark the accurate statements by placing a checkmark (√) in the appropriate spaces.

____ 1. The fitting that serves as a stack base must be positioned and installed when the building drain is fabricated.

____ 2. The blocking under the stack base is not necessary.

____ 3. The building drain fall should not exceed 1/4 inch per foot.

____ 4. The measurements between fittings should be from hub to spigot.

## 2-3. Stacks and Vents

In the last section, you learned that the building drain is that part of the plumbing system under the building which receives the discharge from the soil and waste stacks and carries it to the building sewer. You also learned how to determine the proper size of the drain and how to install it. To continue studying this system, we shall now turn our attention to stacks and vents.

### 219. Given some types of stacks and a list of statements pertaining to stacks and materials, match the stack to the correct statement.

**Types of Stacks and Materials Used.** The stack is a vertical assembly of soil, waste, or vent pipe. Stacks are usually installed in the walls, between the floors of buildings, or in other concealed places. The vertical extension of the stack which projects through the roof is known as the stack vent.

The layout and construction of the stack in a plumbing system probably requires as much knowledge and skill on the part of the plumber as any of the other jobs he may perform. Accurate measurement is necessary to insure proper positioning of the fittings in the stack for soil branches, waste branches, and vent piping to the various fixtures. The fittings and pipe must be assembled in perfect alinement, because most stacks are concealed in walls where space is limited.

There are many types of stacks used in the various plumbing systems. All plumbing systems will have one or more of the following stacks.

*Stack.* The term "stack" is used to identify the vertical main pipe in a plumbing waste system. A particular stack may be further defined by the function it performs in the system.

*Stack group.* Stack group is a term applied to the location of fixtures in relation to the stack so that, by means of proper fittings, vents may be reduced to a minimum.

*Main stack.* Every building in which plumbing is installed should have at least one main stack, which should run undiminished in size and as directly as possible from the building drain to fresh air above the roof. (See fig. 2-13.)

*Waste stack.* A waste stack is the vertical pipe that carries waste from any fixture, except water closets, to a junction with the soil pipe or to the building drain, as shown in figure 2-13. Waste stacks may be as small as 2 inches in diameter; the size of the pipe is determined

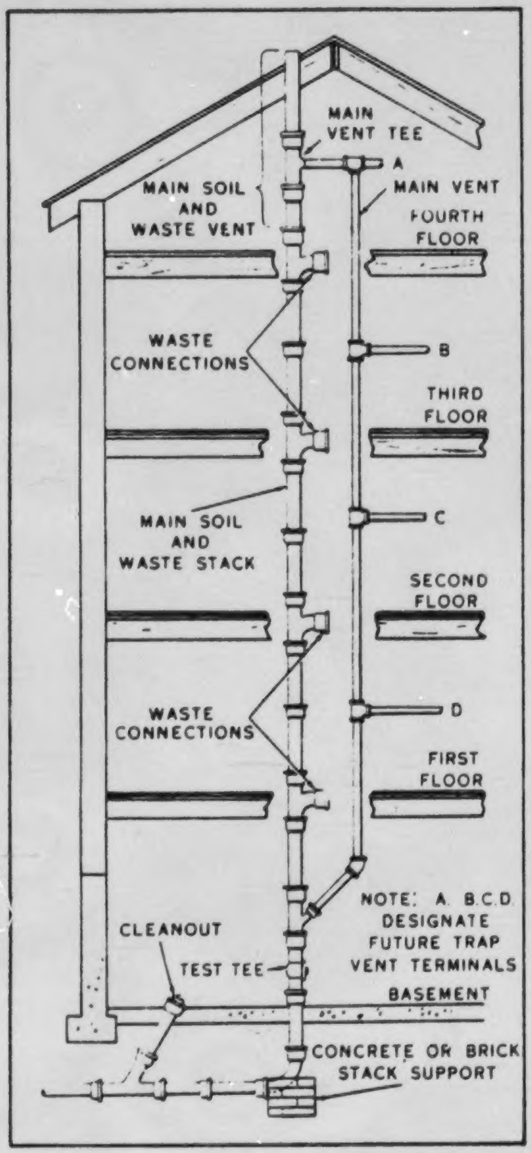

MAIN VENT TEE
A
MAIN SOIL AND WASTE VENT
MAIN VENT
FOURTH FLOOR
WASTE CONNECTIONS
B
THIRD FLOOR
MAIN SOIL AND WASTE STACK
C
SECOND FLOOR
WASTE CONNECTIONS
D
FIRST FLOOR
NOTE: A, B, C, D DESIGNATE FUTURE TRAP VENT TERMINALS
CLEANOUT
TEST TEE
BASEMENT
CONCRETE OR BRICK STACK SUPPORT

Figure 2-14. Soil and waste stack with main vent

by the number and type of fixtures connected to the stack.

*Soil stack.* A soil stack is the vertical main pipe that carries human waste to a junction with a soil pipe or to the building drain, as shown in figure 2-13. The plumbing codes specify that a soil stack must be constructed of pipe with a minimum diameter of 3 inches.

*Soil and waste stack.* A soil and waste stack is a vertical pipe which receives the discharge from soil and waste branches. (See fig. 2-14.)

*Vent stack.* A vent stack is a vertical pipe which provides circulation of air through the drainage system. The vent stack may be constructed on top of a soil stack, but only the portion of the pipe which is above the highest fixture rim or waste branch inlet is considered to be the vent stack, as you can see in figure 2-13.

*Stack vent.* The stack vent is the extension of a soil or waste stack, that portion of the pipe which is above the highest fixture or branch inlet. (See fig. 2-13.)

*Materials.* Stacks and waste pipes may be installed with materials such as bell and spigot cast-iron soil pipe, no-hub cast-iron soil pipe, and galvanized steel, plastic, copper, or brass pipe. The principal objection to the use of copper or brass for soil and waste pipes is its initial high cost: otherwise, it has proven very satisfactory. Usually the engineers specification sheets will specify the type of materials to be used.

**Exercises (219):**

Match the following stacks in column A to the statements in column B by placing the correct term in the space provided.

*Column A*

1. Stack
2. Soil stack
3. Waste stack
4. Vent stack
5. Stack vent

*Column B*

____ a. The vertical main pipe that carries human excrement to a junction with a soil pipe or building drain.

____ b. A vertical pipe which provides circulation of air through the drainage system.

____ c. The vertical main pipe in a plumbing waste system.

____ d. The extension of a soil or waste stack.

____ e. The vertical pipe that carries waste from any fixture except the water closet.

| Diameter of Pipe (Inches) | Fixture Units Per Stack |
|---|---|
| 3 | 60 |
| 4 | 500 |
| 5 | 1,100 |
| 6 | 1,900 |
| 8 | 3,600 |
| 10 | 5,600 |
| 12 | 8,400 |

Figure 2-15. Stack table

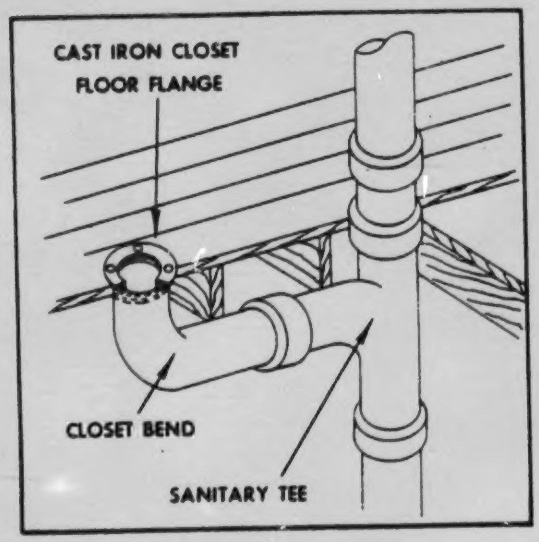


Figure 2-16. Installation of sanitary tee and closet bend.

**220. Select the correct statements pertaining to the sizing of stacks.**

**Sizing the Stack.** The method of sizing the stack is similar to that of sizing a building drain. You must first calculate the maximum unit values of waste discharged into the stack. Do this by using the fixture table in figure 2-11. After determining the total fixture unit values, convert the values to pipe diameter by using the stack table in figure 2-15. The minimum size of pipe used in a stack should be 3 inches in diameter; however, a pipe 4 inches in diameter is preferred.

**Exercises (220):**

Identify the correct statements pertaining to sizing of stacks by placing a checkmark (√) in the appropriate spaces.

____ 1. Calculate the maximum discharge of waste in terms of fixture unit values.
____ 2. Convert the values to pipe diameter.
____ 3. Use minimum number of unit fixture values.
____ 4. Always use a 4-inch soil pipe for the stack.

**221. Provided a list of fittings, select the fitting that should be installed first when assembling a stack and select correct statements concerning stack fittings.**

**Stack Layout.** After you have determined the waste stack and waste connections and have selected the fittings for these connections, you are ready to lay out the stack. But first, you must cut the structural openings for the stack. The stack base should be installed at the time the building drain is fabricated. If no provisions were made for testing or cleaning the drain at the stack base, a test tee should be installed as the first fitting on the stack base. The next fitting installed on a soil stack is usually a sanitary tee to accomodate the soil branch or closet bend. Other fittings are added in their proper order to complete the stack. The measurements for cutting this pipe must be made between the center lines of the fittings. The pipe cuts are made with a hammer and chisel or other appropriate tools. After the pipes are cut, put the stack together for a trial assembly, and doublecheck the measurements for accuracy.

**Exercises (221):**

In exercise 1, select the fitting to be installed first when assembling a stack. Next, select the correct statements by placing a C in the appropriate spaces.

____ 1. (a) Long tee.
  (b) Straight tee.
  (c) Test tee.
  (d) Reducing tee.
____ 2. The second fitting installed on a soil stack is usually a sanitary tee.
____ 3. The stack base is installed after the test tee is installed.
____ 4. You should doublecheck your measurements for accuracy.

**222. Given a list of situations concerning stack assembly, choose those that are correct.**

**Stack Assembly.** The assembly of the stack in a building that is under construction is completed in two operations. The first part of the stack, which is located below the floor level, is constructed first, and then the portion above the floor is completed. The plumber must determine the portion of the work that can be done with the pipe and fittings in place and the portion that must be fabricated before it is set in place. There

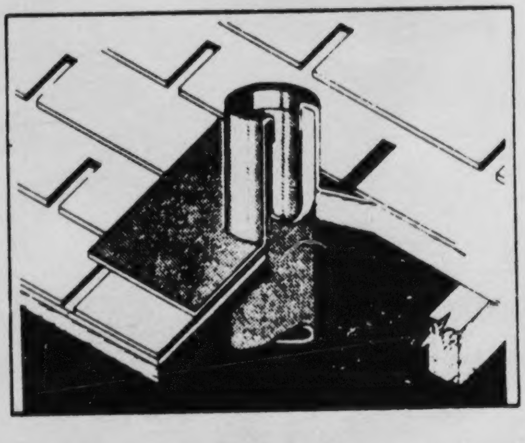


Figure 2-17. Installation of roof vent flashing.

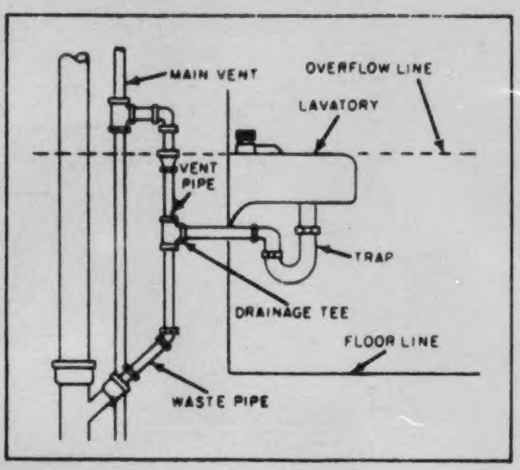

MAIN VENT
OVERFLOW LINE
LAVATORY
VENT PIPE
TRAP
DRAINAGE TEE
FLOOR LINE
WASTE PIPE

Figure 2-18. Single fixture individually vented.

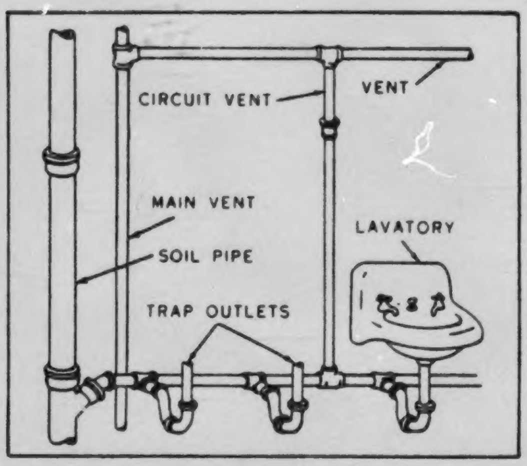

CIRCUIT VENT
VENT
MAIN VENT
LAVATORY
SOIL PIPE
TRAP OUTLETS

Figure 2-20. Battery of lavatories circuit vented.

must be sufficient space around the fittings to use the oakum and lead packing tools and the necessary head room for pouring molten lead into the joints. The installation of a sanitary tee and closet bend beneath a subfloor and between the floor joists is shown in figure 2-16. This portion of the stack must be fabricated before it is placed in its final position, because the working area is too small.

The fittings must be alined so that the hubs are within the confines of the wall area when you install the portion of the stack above the floor level, because that part of the stack is usually encased in the wall. When portions of the stack are assembled before the wall is framed, use a carpenter's level to insure that the stack is constructed in a truly vertical position.

After the stack is completed, brace it with wood supports at the branch openings to prevent it from moving or shifting. In multistory construction, the stack should be supported as it passes through each floor level. The pipe horizontal to the stack should be supported near its connection to the stack. This will support the weight of the horizontal pipe and lessen the stress on the stack.

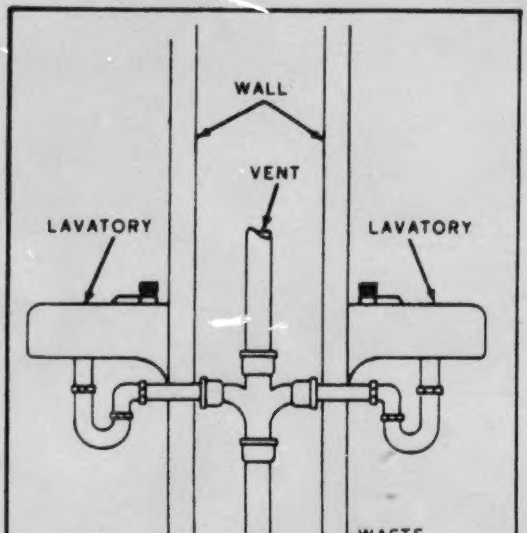

WALL
VENT
LAVATORY
LAVATORY
WASTE

Figure 2-19. Pair of fixtures unit vented.

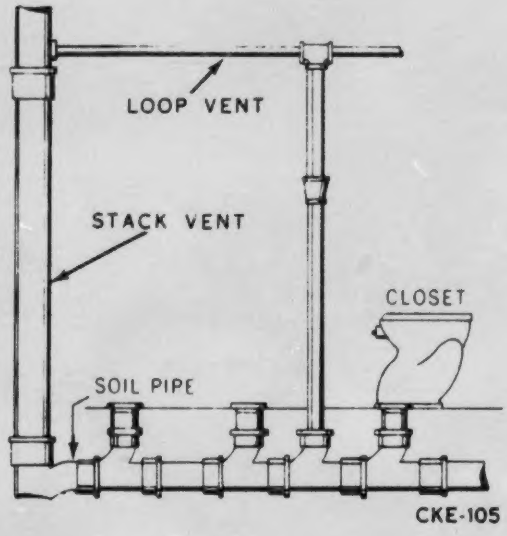

LOOP VENT
STACK VENT
CLOSET
SOIL PIPE
CKE-105

Figure 2-21. Water closet battery loop vent.

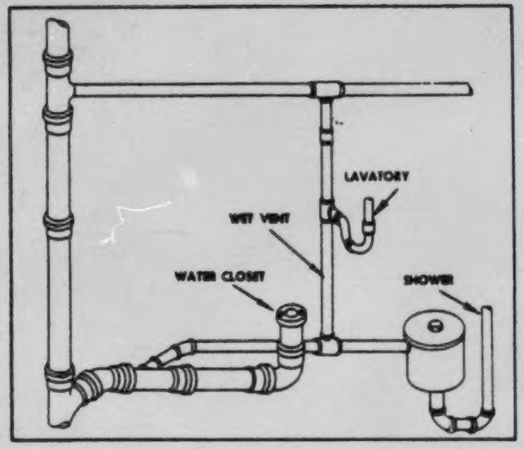


Figure 2-22. Group of fixtures with wet vents.

**Exercises (222):**

Choose the correct situations by placing an X in the spaces provided.

____ 1. The assembly of the stack in a building under construction is completed in two operations.

____ 2. The fittings must be alined so that they are within the confines of the wall.

____ 3. A transit should be used to aline the stack in a vertical position.

____ 4. The stack should be supported as it passes through each floor level.

**223. Provided a list of statements associated with topping out stacks, mark the true statements.**

**Topping Out of Stacks.** After the stack is completed, it is run through the roof to form a vent terminal. The pipe through the roof must be full size or larger and must project through the roof at least 6 inches. Raising the stack through the roof and installing the roof flashing, as shown in figure 2-17, is a simple procedure on new installations before the roof is shingled. Cutting the hole and placing the roof flashing to secure a leakproof projection of the stack through the roof is more difficult when you are remodeling an old building where the roof is already installed. The opening in the roof is made watertight by roof flashings. On shingled roofs, extend the roof flashing under two courses of shingles above the pipe. On flat roofs, place the flashing between layers of roofing material with the finishing layer over the top of the flashing. Roof flashings are available in a number of different sizes, and the size of flashing used depends upon the size of the main and waste vents, which are the portions of the stack that project through the roof, as shown in figure 2-13. In certain areas of the country, it is possible for frost to close the vent at the roof outlet when the vent is exposed to temperatures below freezing. The air within the stack and vent pipes in the building is usually very close to the moisture saturation point. When this very humid air is emitted from the main and waste vent, it condenses and freezes if it is exposed to extremely cold temperatures. One way to prevent frost from closing the vent is to increase the pipe a size or two larger than the vertical stack. Another method that can be used in extremely cold climates is to install a high lead flashing, which provides an insulating pocket of air between the flashing and the end of the main and waste vent above the roof. The air pocket is open to the heat of the building and provides an intermediate warming area for gases leaving the main soil and waste vent.

**Exercises (223):**

Mark the true statements by placing a T in the spaces provided.

____ 1. The stack must extend through the roof full size or larger.

____ 2. The structural opening where the stack passes through is sealed by a roof flashing.

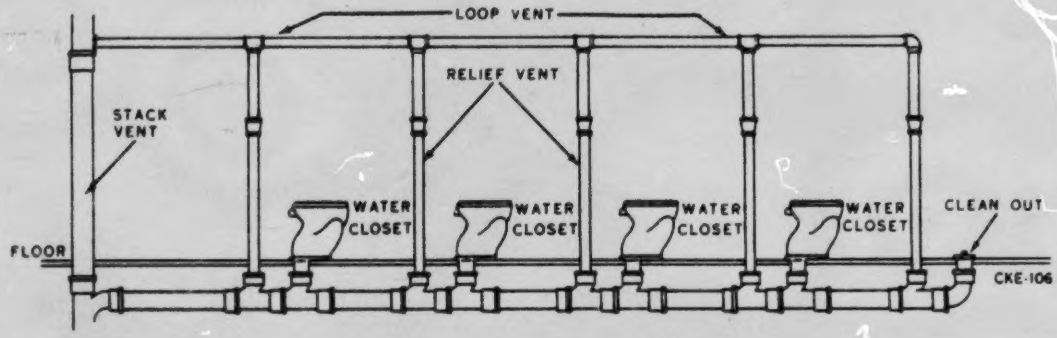


Figure 2-23. A group of fixtures relief vented.

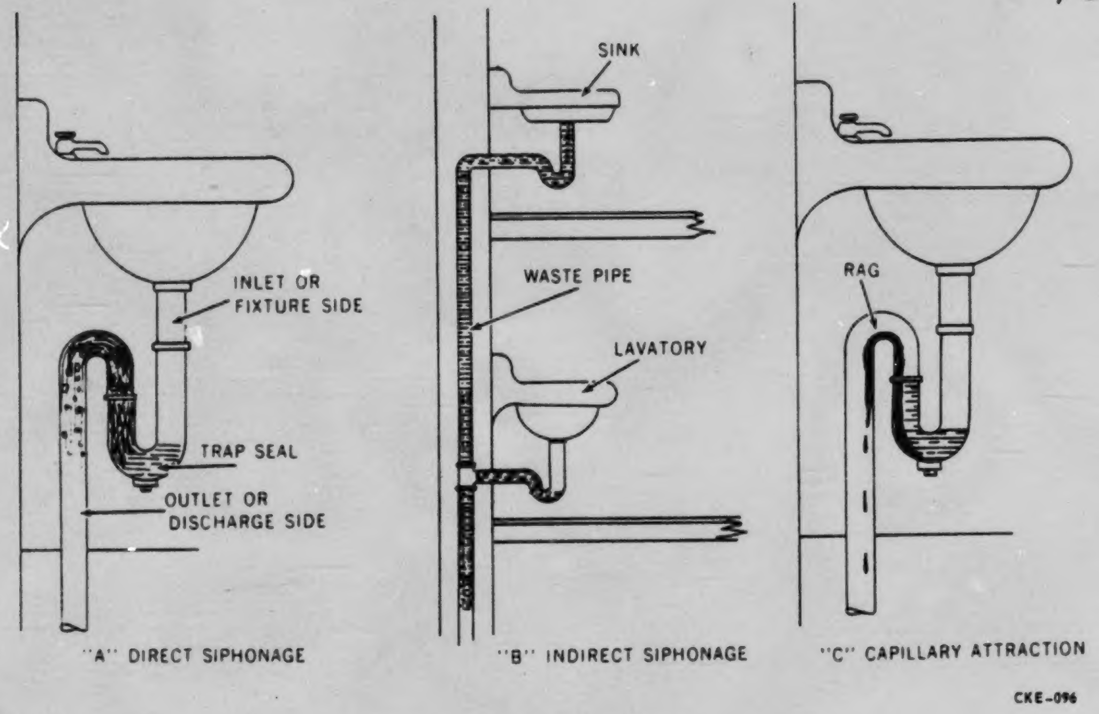


Figure 2-24. Loss of water seal.

____ 3. One way to prevent frost buildup in the stack is to extend its length by 6 inches.
____ 4. Stacks should extend through roofs at least 6 inches.

**224. Match the definition of vents to the specific types of vents.**

**Types of Vents.** There are several approved methods for venting a plumbing system. The type of vent that is used depends upon the design of the building, the number of fixtures, and the manner in which they are grouped. On small, single-story plumbing installations, where the fixtures are grouped and located so that the fixture traps attach directly to the fittings in the stack, no additional venting is necessary other than the stack vent. In buildings where the fixtures are located away from the stacks or in multistory buildings where fixtures are installed in the upper floors, a main vent, as shown in figure 2-14, may be necessary to insure adequate venting for the system. The types of vents, of which you may find one or more in a vent installation, are the main, individual, unit, circuit, loop, wet, and relief vents.

*Main vent.* The main vent is a vertical vent pipe that runs parallel to the soil or waste stack and serves as a terminal for the vent piping from the individual fixtures. It is an integral part of the vent system of a plumbing installation and is constructed in conjunction with the waste stack. The main vent connects full size at its base into the soil or waste stack through a Y-fitting at a point below the lowest fixture branch. It extends full size through and above the roof or to a point of connection with the stack vent above the highest fixture branch. The fitting for this connection is referred to as the main vent tee, which is also shown in figure 2-14. In most installations, the main vent is located within a few feet of the waste stack, but it may be offset as much as necessary where special problems exist. Notice the location of the waste connections in the main stack in figure 2-14 and also the future trap vent terminals, which are designated by A, B, C, and D and will be used for venting purposes only.

*Individual vent.* The installation of a single fixture when a main vent is used is illustrated in figure 2-18. Notice the drainage through the waste pipe to the waste stack. The vent pipe above the trap is connected to the main vent. This method of venting a fixture is referred to as an individual vent. The vent piping must rise vertically at least 6 inches above the fixture rim before changing the direction for connection to the main vent. The fixture is said to be dry vented, because there is no drainage flow through the vent piping in the system. The individual vent is the most popular type of vent installation used in plumbing systems. It is adaptable to all types of fixtures and prevents both direct and indirect siphoning.

*Unit vent.* Fixtures that are mounted side by side or back to back on a wall, as shown in figure 2-19, are unit vented. A unit vent, sometimes called a dual vent, is a vent pipe installed to protect two fixture traps. The vent pipe connects to the main vent when a stack is located nearby or may extend individually through the roof. When the vent extends through the roof, the vertical pipe may be referred to as a unit vent and drain instead of a waste stack.

*Circuit vent.* A battery of fixtures, such as a group of lavatories in a large public latrine, may be circuit vented. A circuit vent extends from the main vent to connections on the horizontal soil or waste branch pipe between the fixture connections, as shown in figure 2-20. The maximum number of lavatories or other fixtures that are permitted on any one vent circuit is eight.

*Loop vent.* A loop vent is similar to the circuit vent, except it ties into the soil or waste stack. This type of vent is used primarily in single story buildings, but it may be used on the top floor of multistory buildings. Figure 2-21 illustrates a water closet battery loop vent.

*Wet vent.* Sometimes it is permissible to wet vent a fixture trap. A wet vent is that portion of the pipe through which liquid wastes must flow from another fixture which is itself individually vented. A shower trap which is wet vented through the lavatory waste pipe is illustrated in figure 2-22.

*Relief vent.* A relief vent (see fig. 2-23) is installed to prevent excessive pressure from developing in the drainage system that may cause siphonage or back pressure to nearby fixtures. This pressure is relieved at congested points where the flow tends to develop slugs, causing overloads on the drainage system because of the lack of proper air circulation.

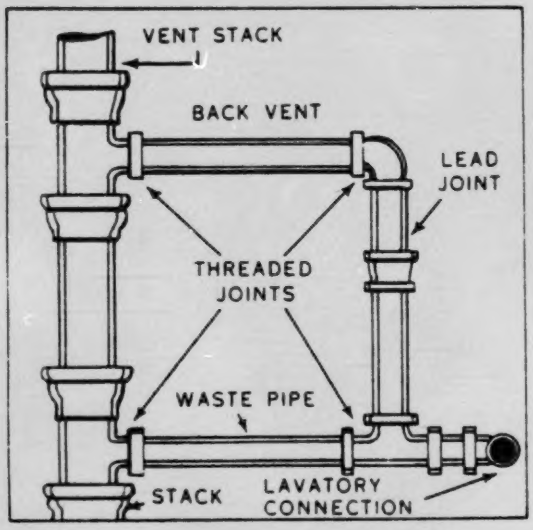


Figure 2-25. Lavatory back vented

Where water flowing in a horizontal pipe is offset to a vertical, there is a tendency for the water to accelerate and it could siphon the fixtures installed close to the offset. A relief vent dissipates this negative pressure by introducing air and prevents siphonage of the fixture traps in its path. Whenever the water in a trap is removed, the trap loses its seal. Trap seal loss is usually caused by direct siphonage, indirect siphonage, evaporation, or capillary action. (See fig. 2-24.)

*Back vent.* In most one-story plumbing installations where the lavatory is near the stack, it drains through a waste pipe into the soil or waste stack. The lavatory is then vented into the stack above the drain, as shown in figure 2-25. This is referred to as a back vent.

**Exercises (224):**

Match the vent in column A with the correct definition in column B.

*Column A*

Unit.
Relief.
Main.
Loop.

*Column B*

1. A ____ vent is a vertical vent pipe that runs parallel to the soil or waste stack.
2. A ____ vent vents fixtures mounted side by side.
3. A ____ vent vents a battery of fixtures in a single story building.
4. A ____ vent prevents excessive pressure from developing in the drainage system.

**225. Match the type of trap seal loss with its definition.**

**Trap Seal Loss.** Whenever the water in a trap is removed, the trap loses its seal. Trap seal loss is usually caused by capillary action, direct siphoning, indirect siphoning, and evaporation.

*Capillary action.* The loss of the water seal in a trap due to capillary action is caused by some foreign object lodged in the trap; the object acts as a wick and carries the water from the trap over the outlet side down the drain. The common objects that may cause this problem are rags, lint, string, and hair.

*Direct siphoning.* Direct siphoning is the result of a pressure lower than atmospheric pressure on the discharge side of a trap. This condition allows the atmospheric pressure on the fixture side of the trap to push the water seal through the trap and down into the waste pipe. Direct siphoning usually occurs when using unvented traps which serve lavatories.

*Indirect siphoning.* Indirect siphoning is the loss of the water seal in a trap, sometimes referred to as siphoning by momentum, caused by the discharge of a large volume of water from a fixture that is installed one or more floor levels above the affected fixture and trap. The discharge of the water tends to reduce the pressure on the discharge side of the trap and thus to break the seal.

*Evaporation.* The loss of the water seal in a trap caused by evaporation is not as important as a loss caused by either direct or indirect siphoning. The loss of water from a trap by evaporation occurs only when the fixture is not used for a considerable length of time. The rate of evaporation of the water in a trap depends upon the humidity and temperature of the atmosphere. A trap located in a place where the temperature is high and the air is dry will tend to lose its water seal by evaporation more rapidly than one in a cool and damp room. It is difficult to stop the evaporation of water from a trap when it is being used only occassionally, but the installation of a deep seal trap is a partial solution. A deep seal trap has a water seal of about 4 inches instead of the usual 2 inches. Since there is more water in a deep seal trap, it takes a longer time to evaporate the water and break the seal.

**Exercise (225):**

Match the type of trap seal loss in column A with the correct definition in column B by placing the appropriate letter in the spaces provided.

*Column A*

a. Direct siphonage.
b. Indirect siphonage.
c. Capillary action.

*Column B*

____ 1. Trap seal loss caused by foreign objects lodged in trap.
____ 2. Trap seal loss as a result of a pressure lower than atmospheric pressure on the discharge side of the trap.
____ 3. Trap seal loss caused by momentum.

## CHAPTER 3

# Roughing-In Vents and Waste Lines

THE ROUGH-IN for the fixture vents and waste lines is done after the subfloor, studs, and roof are installed when a building is being erected. However, in some types of building construction, part of the plumbing is placed below the concrete floor. Since vents and waste lines are installed at different times in different types of construction, it is very important for you to know when to install them in order to save expense and time. This chapter covers waste rough-in for lavatories, urinals, bathtubs, showers, water closets, and floor and roof drains.

### 3-1. Waste Rough-In for Lavatories

Be sure you have a working drawing to follow when you install the waste rough-in plumbing for a lavatory. The right type of vent system and the correct installation of the waste pipes are necessary to insure proper operation of the lavatory with a minimum amount of maintenance.

**226. Given a list of statements and responses concerning vents, match the correct responses to the statements.**

**Planning the Installation.** The seal for each fixture trap in a plumbing system should be protected from siphoning by a properly installed vent pipe. The type of vent used is determined by the number and location of the fixtures and the building layout. Fittings for vent pipe connections must be located and installed in the stack at the time the stack is laid out and fabricated. The fittings must have the proper sized hub or tapped branch openings for connecting the vent pipe. The table shown in figure 3-1 indicates the pipe sizes for vent lines to various types of fixtures.

Plumbing codes regulate the size of pipe for a particular type of vent. The size of the pipe used for a soil stack vent or a waste stack vent must be no less than the diameter of the soil or waste stack pipe. When a main vent is added to a stack, the main vent pipe must have a diameter of at least one-half the diameter of the stack it serves, but in no case can the main vent pipe be less than 1¼ inches in diameter.

The diameter of an individual vent pipe may not be less than 1¼ inches and should not be less than one-half the diameter of the waste pipe to which it is connected. The diameter of a circuit or loop vent may not be less than the diameter of the soil or waste branch or the main vent diameter, whichever is the smaller.

The vent pipe should be free of traps and connected in a manner so that any liquid in the pipe will drip back into the stack by gravity flow. Pipe used for vents may be made of cast iron, wrought iron, steel, copper, or plastic. Iron pipe is preferred for small-sized vents because it is easily installed. Threaded fittings through which waste water passes should be of the recessed type to avoid stoppages.

**Exercises (226):**

Match the correct responses to the statements by placing the appropriate letter(s) (a, b, c, or d) in the spaces provided.

| *Statements* | *Responses* |
|---|---|
| ___ 1. When a main vent is added to a stack, the main vent pipe must be at least | a. 1¼ inch. |
| ___ 2. The diameter of an individual vent pipe should not be less than | b. one-half the size of the stack it serves. |
| ___ 3. A circuit vent must not be less than the diameter of the | c. free of traps |
| ___ 4. The vent pipe must be | d. soil branch it serves |

| Fixture | Minimum size of vent in inches |
|---|---|
| Lavatory | 1 1/4 |
| Drinking fountain | 1 1/4 |
| Sink | 1 1/2 |
| Shower | 1 1/2 |
| Bathtub | 1 1/2 |
| Laundry tub | 1 1/2 |
| Slop sink | 1 1/2 |
| Water closet | 2 |

Figure 3-1. Individual fixture vent sizes

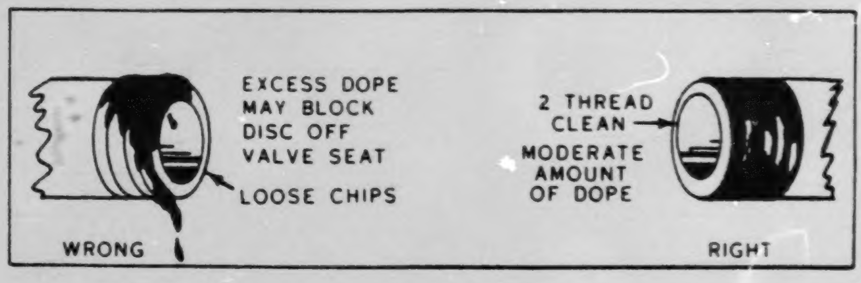


Figure 3-2. Applying pipe compound to a pipe.

**227. From a group of statements relating to lavatory drains and vents, choose those that are correct.**

**Assembly of Lavatory Drain and Vent.** When roughing-in a lavatory, you should refer to a work drawing as you make the installation. The vent and waste pipes for lavatories should be constructed of cast-iron pipe with calked joints, plastic pipe with solvent-welded joints, copper pipe with soldered joints, or galvanized steel pipe and threaded fittings. The individual fixture vent pipe is usually installed with galvanized pipe fittings. Drainage type fittings, which have a sweeping effect, should be used rather than regular straight fittings. Drainage type fittings offer less resistance to the flow of liquid or the movement of air at points where the direction of the pipe changes.

When cast-iron soil pipe is used for fabricating the waste line to a lavatory, the cast-iron pipe and fittings should be installed before the vent lines. The joints should be calked with oakum and lead to make a gastight and watertight seal. When galvanized pipe and fittings are used for the waste pipe, the vent and waste pipe can be installed as a continuous operation. Coat the male thread with a joint compound, as shown in figure 3-2. Apply a light coat of compound and leave at least two threads on the pipe end free of the compound. There are several reasons for using thread compounds. They may be used as a lubricant during the assembly of pipe joints, as a sealing agent for the joint, as a corrosion-protective agent for the joint, or as an antiseize compound (a compound used to prevent excessive binding or tightness) in case the joints must be disassembled later.

When you make up pipe, start the fitting onto the male thread of the pipe. Make sure the threads are not crossed. The fitting and pipe should screw together easily by hand for two or three turns before you have to use a wrench. Use a pipe wrench to screw the fitting onto the pipe until the desired degree of tightness is obtained. When a fitting is made up properly on a pipe which has threads of the proper length, two or three threads will show in the pipe beyond the butt of the fitting. Special care should be taken against overtightening fittings. A fitting should never be "backed off" to obtain a certain directional change. If a fitting is screwed on a pipe too far, it may crack or stretch and cause a leak.

When you fabricate a loop or circuit from threaded pipe and fittings, you cannot make the final connection to a regular threaded fitting. Pipe unions are designed for this type of connection, but plumbing codes do not allow pipe unions to be used in concealed drain or vent piping. The practice of cutting an extra long thread on a pipe so it can be screwed deep into one fitting and then backed out as it is screwed into another fitting is also prohibited. This method of final connection usually causes leakage on the end of the pipe which has the long thread.

A special sleeve coupling known as the Tucker connection, illustrated in figure 3-3, is recommended for making the final joint in a loop of pipe. This special fitting is designed with a female thread in the

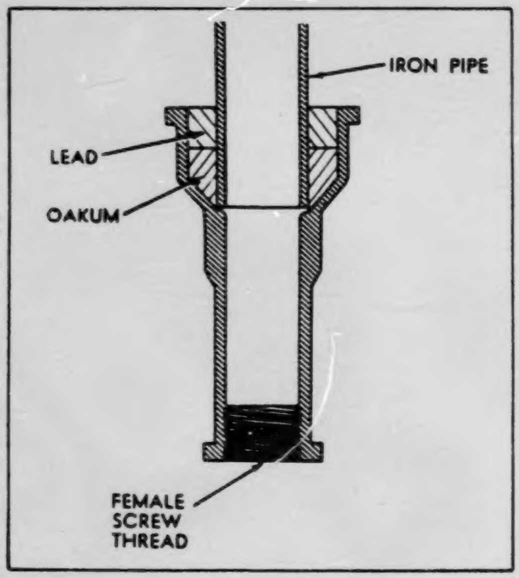


Figure 3-3. Tucker connection.

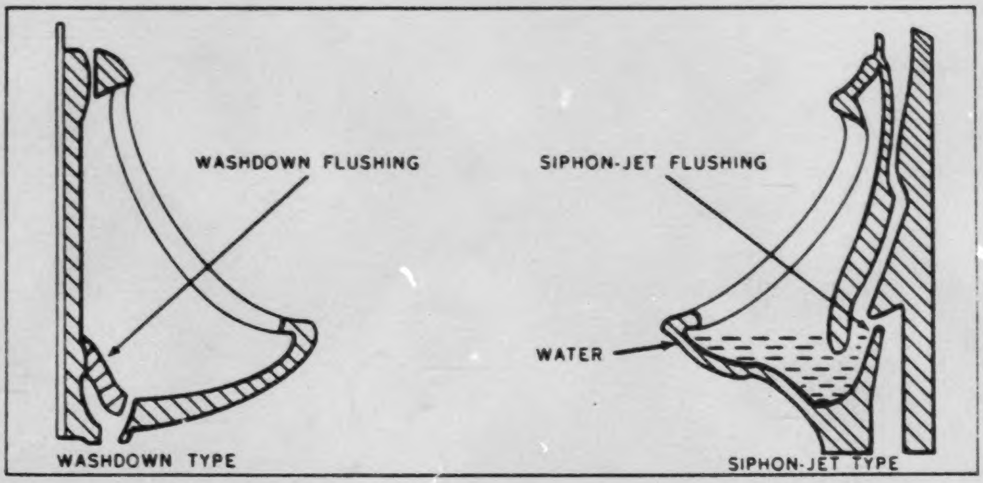


Figure 3-4. Types of wall-hung urinals.

smaller end for screwing onto a threaded pipe, and the larger end is designed with a bell to slip over the other pipe for making a calked joint. The bell is extra deep in order to allow the pipe to drop down far enough so the other end of the pipe can be screwed into a fitting. The bell joint on the coupling is calked with oakum and lead to make a final connection in the piping.

The horizontal vent pipes should be installed with a fall of 1/4 inch per foot so that moisture can drain by gravity flow into the stack or waste line. Screw type drainage fittings should be used rather than straight fittings, because the inlets on the drainage fittings are tapped with a pitch of 1/4 inch to the foot. The nipples, which are installed in fittings to accommodate lavatory traps, should be long enough to allow the connection of the trap after the finished wall is installed.

**Exercises (227):**

Choose the correct statements by placing a C in the appropriate spaces.

____ 1. Drainage fittings offer less resistance to flow of liquid than regular fittings.
____ 2. You may back off a fitting one-fourth of a turn to aline it with the pipe.
____ 3. A Tucker connection is used to tie in a loop of pipe.
____ 4. Horizontal vent pipes should be installed with a 1/4-inch fall.

## 3-2. Waste Rough-In for Urinals

The installation of vents and waste pipes for urinals is similar to the installation of vents and waste pipes for lavatories. Be sure you get the rough-in measurements for the urinal that you are going to install. Some urinals are designed with build-in traps, whereas others need external traps.

### 228. Provide answers for pertinent questions related to urinal drains and venting methods.

**Urinal Drainage and Vent Methods.** The waste and vent lines for urinals are very similar in design and construction to those of lavatories. The type of urinal to be installed determines the design of the waste and vent systems. There are four basic types of urinals: the trough, the stall, the wall-hung, and the pedestal. The trough and the stall type of urinals are not approved for new Air Force construction or maintenance replacement. As a result, you will be primarily concerned with the installation and maintenance of the wall-hung and pedestal type urinals. These urinals operate on one of two types of flushing operations, and this in turn determines the method recommended for venting the fixture trap. Wall-hung and pedestal type urinals have either a washdown or a siphon-jet flushing action. The washdown type usually has an external trap. Wall-hung and pedestal type urinals have traps built into the fixture. A cross section of both types of urinals is shown in figure 3-4. In the washdown type, the bowl does not carry a body of water to dilute the urine which remains in the bowl unless it is flushed each time after it is used. Since the urine is not always washed out of the bowl, it gives off an offensive odor. This condition is aided considerably in the siphon-jet type, because there is at all times a body of water in the bowl so that the urine is diluted as soon as it enters the bowl.

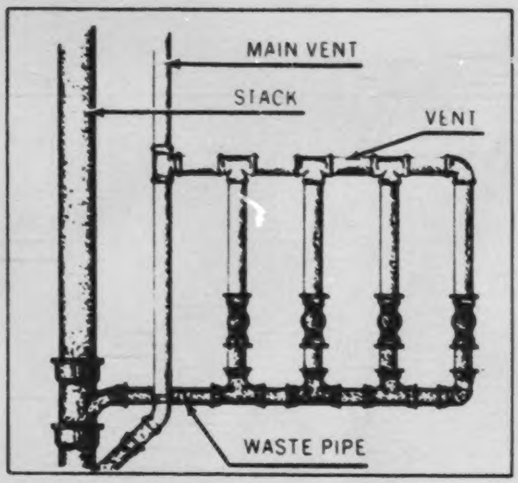


Figure 3-5. Individual venting of washdown urinals

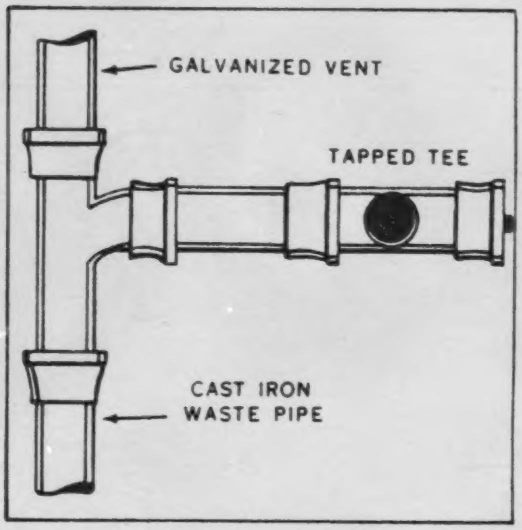


Figure 3-7. Vent and drain for a single siphon-jet urinal.

The minimum size of waste pipe that can be used for draining an individual urinal is 2 inches. This waste pipe should be fabricated of cast-iron pipe and fittings because of the high acid content of the urine. Vent pipes above the fixture may be constructed of galvanized pipe and fittings. The minimum size of vent pipe allowed for an individual urinal is 1 1/2 inches, or not less than one-half the diameter of the waste pipe which it vents, whichever measurement is the larger.

The rough-in plumbing for a battery of wall-hung urinals that have a washdown flushing action should be installed as shown in figure 3-5. Each trap is individually vented into a circuit vent, which in turn is vented either through the roof or to a main vent. The rough-in plumbing for a battery of urinals which have a siphon-jet flushing action should be installed so that the urinals are dual vented, as shown in figure 3-6. The short run or horizontal waste pipe from the fitting on the vertical waste pipe to the fixture trap enables the siphon-jet flushing action of the urinal to operate more efficiently.

When a single urinal is installed, as in a restroom, the procedure depends upon the type of urinal. If a washdown type of urinal is installed, it should be individually vented, and the fixture trap may be

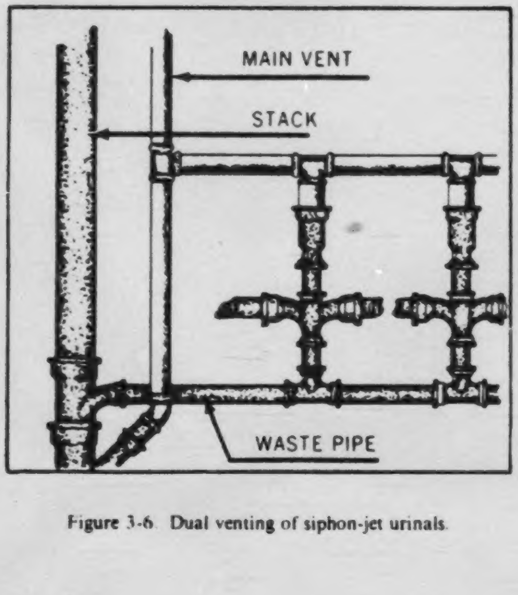


Figure 3-6. Dual venting of siphon-jet urinals.

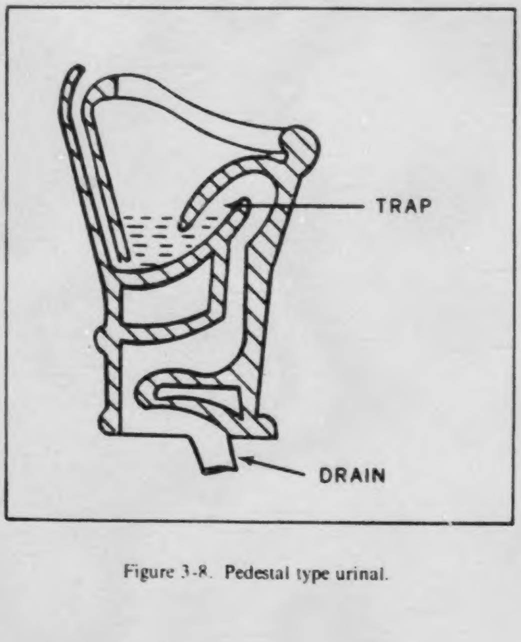


Figure 3-8. Pedestal type urinal.

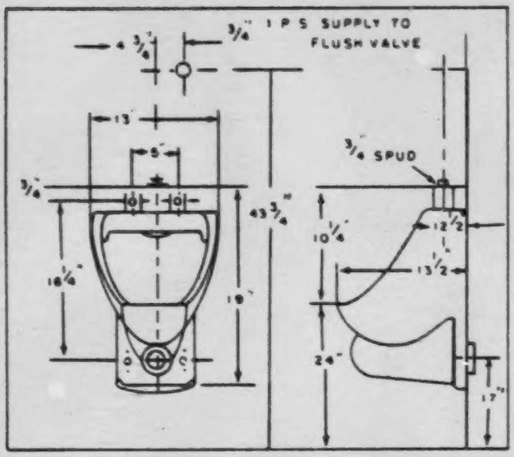


Figure 3-9. Manufacturer's rough-in specifications sheet for a wall hung urinal.

connected directly into a fitting on a vertical waste pipe. However, when a siphon-jet urinal is installed, a short run of horizontal waste pipe should be placed between the fitting on the vertical waste pipe and the fixture, as shown in figure 3-7. The siphon flushing action is more efficient in operation when the fixture trap does not discharge directly into a vertical waste pipe. This horizontal waste branch can be up to 5 feet in length before additional venting is required.

Some plumbing codes allow circuit venting of as many as eight urinals into one circuit vent. This practice is not recommended for wall-hung urinals, because it has been proven that individual or dual venting into a circuit vent prevents many stoppages in the waste piping.

Circuit venting of pedestal type urinals, like the one shown in figure 3-8, is permitted when the urinals discharge directly into a horizontal soil or waste pipe.

**Exercises (228):**

Provide brief answers for the following questions.

1. What are the two types of flushing action for urinals?

2. What is the minimum size waste pipe that can be used for an individual drain?

3. What is the minimum size vent that can be used for an individual urinal?

4. Why should you install a short horizontal run of waste pipe when installing a siphon-jet urinal?

**229. Given statements concerning the location of urinals, mark those that are true.**

**Location of Urinals.** When you install waste pipe for a urinal, you should consult the manufacturer's rough-in specifications for the exact installation measurement. The waste pipe must be located so that the lip of the urinal is from 22 to 25 inches above the floor. The manufacturer's rough-in specification sheet for a wall-hung urinal which has an integral trap is illustrated in figure 3-9.

As you can see, the drain must be positioned exactly as indicated in the rough-in specifications to insure that the lip of the urinal is at the proper height. There is no flexibility in the measurement because the urinal has an integral trap. Some variation in measurement is allowed for urinals which have external traps that are attached after the fixture is hung because of the length of the tailpiece or the type of trap that is used.

**Exercises (229):**

Mark the true items by placing a T in the spaces provided.

____ 1. When you rough-in urinals you should consult the manufacturer's specifications.

____ 2. Rough-in measurements for urinals with integral traps have a plus or minus of 1/2 inch.

____ 3. Waste pipe rough-ins for urinals must be located so that the lip of the urinal is within 22 to 25 inches above the floor.

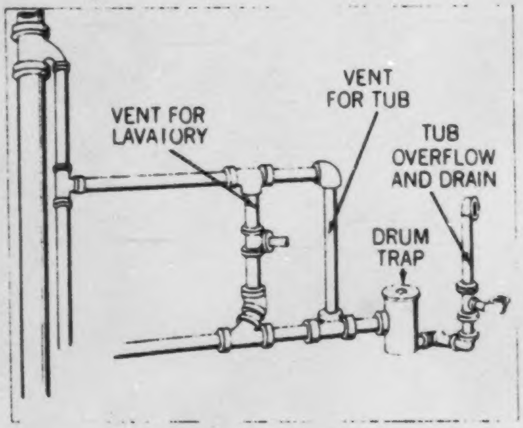


Figure 3-10. Rough-in plumbing for a small bathroom

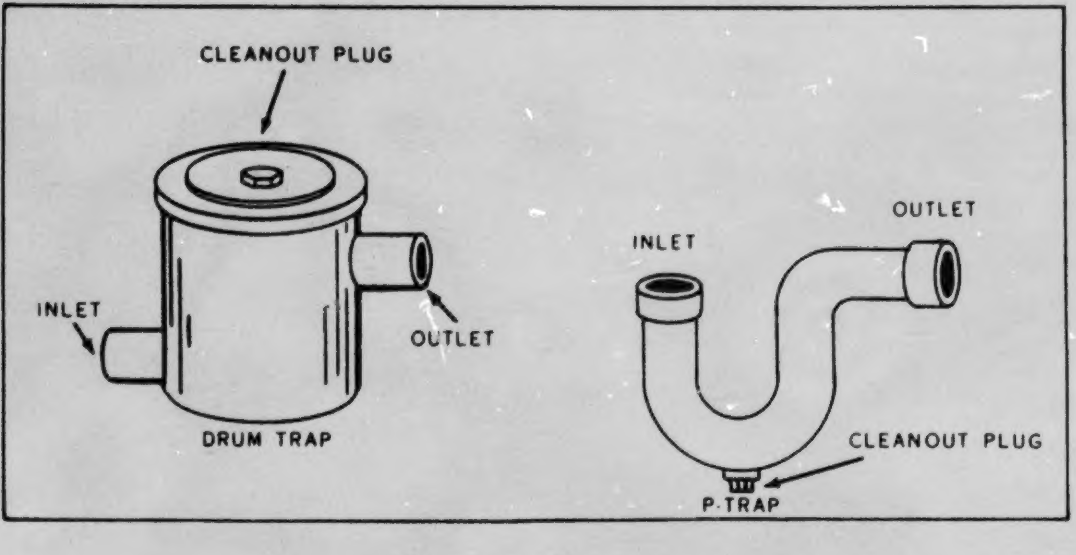

CLEANOUT PLUG
INLET
OUTLET
DRUM TRAP
INLET
OUTLET
CLEANOUT PLUG
P-TRAP

Figure 3-11. Traps for bathtubs and showers.

**230. Provided a list of statements pertaining to urinal drains and vents, identify the correct statements.**

**Assembly of Urinal Vent and Drain.** Cast-iron soil pipe is usually used to fabricate the waste line to the urinal. The cast-iron pipe and fittings are installed before the vent lines. The joints are calked with oakum and lead to make a gastight and watertight seal. The waste lines are installed with a fall 1/4 inch per foot to insure proper drainage.

The vent lines may be fabricated of galvanized pipe and drainage fittings. The horizontal vent lines should be installed with a fall of 1/4 inch per foot so that moisture can drain by gravity flow into a stack or waste pipe. Screw type drainage fittings should be used rather than straight fittings, because the inlets on the drainage fittings are tapped with a pitch of 1/4 inch per foot.

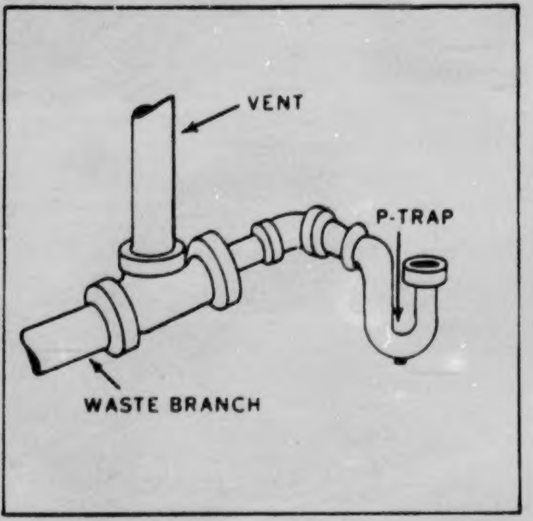

VENT
P-TRAP
WASTE BRANCH

Figure 3-12. Venting a P-trap for a bathtub.

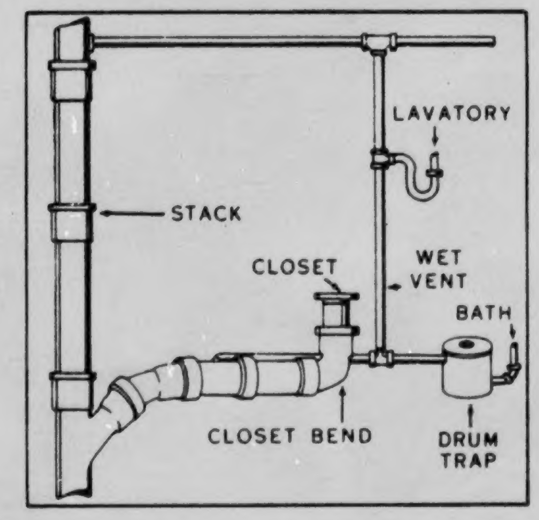

LAVATORY
STACK
CLOSET
WET VENT
BATH
CLOSET BEND
DRUM TRAP

Figure 3-13. Drum trap wet vented through lavatory waste piping.

The pipes or nipples, which are installed in fittings to accommodate the traps in the urinals, should be long enough to allow the connection of the trap after the finished wall is installed.

**Exercises (230):**

Identify the correct statements by placing a checkmark (√) in the appropriate spaces.

____ 1. Cast-iron soil pipe is used to fabricate waste lines for urinals.

____ 2. Waste lines for urinals are installed with a fall of 3/8 inch per foot.

____ 3. Drainage fittings are tapped with a pitch of 1/4 inch per foot.

____ 4. Pipes or nipples are installed to accommodate traps for urinals.

### 3-3. Waste Rough-In for Bathtubs and Showers

The installation of waste branches for draining bathtubs and showers is very similar to the installation of the waste branches for lavatories and urinals. Quality workmanship is necessary in order to insure proper operation of the drains with a minimum of maintenance. The trap is included in the rough-in plumbing for a tub or shower, and the type of trap used partially determines the design of the vent piping.

### 231. Identify the correct statements concerning vents and drains for bathtubs and showers.

**Bathtub and Shower Vents and Drains.** Waste lines for draining bathtubs and showers are usually located below the floor level on which the fixtures are installed. In small residential bathrooms, the tub is normally positioned so that the waste and vent pipes which serve it also serve other fixtures in the bathroom, as shown in figure 3-10. The tub overflow and drain assembly is not included in the rough-in piping, because it is attached directly to the tub at the time the tub is set. The drum trap is included in the rough-in plumbing and must be installed when the waste line is installed. The minimum size for a waste pipe for a bathtub is 1½ inches. When a shower head is installed over the tub, no increase in the size of the waste pipe is necessary.

The rough-in waste pipe should be a minimum of 2 inches in diameter when a single shower is installed. A shower room with a gang of showerheads, such as those used in Air Force buildings where men are quartered, requires a waste pipe of 3 or 4 inches in diameter to handle the high volume of flow during peak periods of use.

There are two types of traps used for bathtub and shower combination. They are the drum trap and P-trap, shown in figure 3-11.

P-traps for bathtubs are made of either cast iron or cast bronze and must have a cleanout plug located in the bottom of the trap dip. Both the inlet and outlet of the trap have female threads. When the P-trap is used, the waste pipe must have a vent pipe installed on the outlet side of the trap as near the trap as possible, as shown in figure 3-12. However, if the trap cannot be vented or is wet vented through a drain from another fixture, the drum trap should be used. The drum trap is the most acceptable type to use in this case, because the water seal in it is difficult to break by siphoning. A drum trap that is wet vented through the lavatory waste line is illustrated in figure 3-13.

**Exercise (231):**

1. From the following list, select the correct statements.
   a. The minimum size waste pipe for a bathtub is 1½ inches.
   b. The minimum size waste pipe for an individual shower is 2 inches.
   c. Gang showers should have a 2- to 3-inch waste pipe.
   d. A P-trap or drum trap may be used on bathtub and shower combinations.

### 232. Identify the true statements pertaining to location of bathtubs and showers.

**Location of Bathtubs and Showers.** You should use the manufacturer's specification sheets to rough-in bathtubs and showers. When drum traps are used, the waste line must be routed in such a manner that the position of the top of the drum trap is flush with the floor surface. You should know the type of bathtub overflow and waste line which is installed on the tub when you determine the position of the inlet to the waste pipe for the tub. You must position the drain inlet correctly in order to fit the tailpiece of the tub overflow and waste line when you install the tub. You should also note the other dimensions so that you will not have to redo the roughed-in plumbing when you install the fixtures in the building.

**Exercises (232):**

Identify the true statements by placing a T in the spaces provided.

____ 1. You should consult the manufacturer's specification sheets when you rough-in bathtubs and showers.

____ 2. The bottom of a drum trap should be flush with the finished floor.

____ 3. You should know the type of overflow and waste line when roughing-in a bathtub in order to aline the waste pipe.

### 233. Give required information concerning the assembly of bathtub and shower vents and drains.

**Assembly of Bathtub and Shower Vents and Drains.** The waste branch for draining baths may be constructed of galvanized steel pipe and drainage

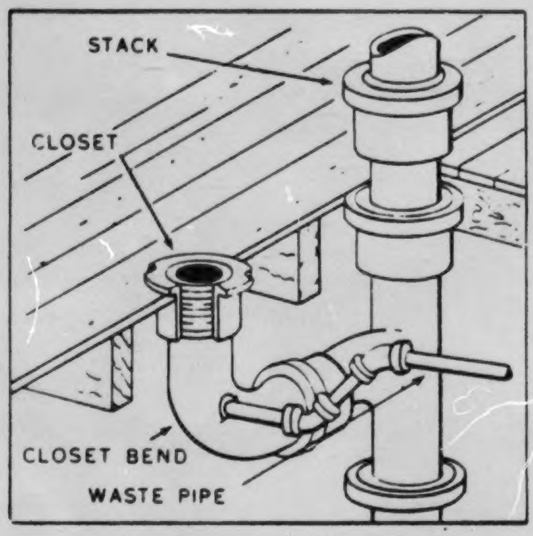


Figure 3-14. Discharging bathtub and shower waste into a closet bend

fittings. Changes in pipe size are made with reducing fittings, but the size of the pipe cannot be reduced between the trap and the point of discharge of the bath waste pipe. Tucker or hub drainage fittings are used for making union connections in conjunction with dry vents. The use of long screw threads in bushings for making connections is prohibited.

Waste pipes from bathtubs and showers usually discharge into a stack. In small residences where the bath fixtures are grouped in a small room, the waste pipe may discharge into the closet bend, as illustrated in figure 3-14, and the fixture traps may be back vented into the vent stack.

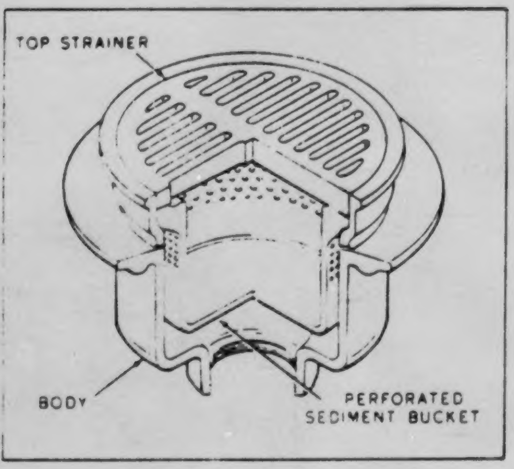


Figure 3-15. Typical shower drain.

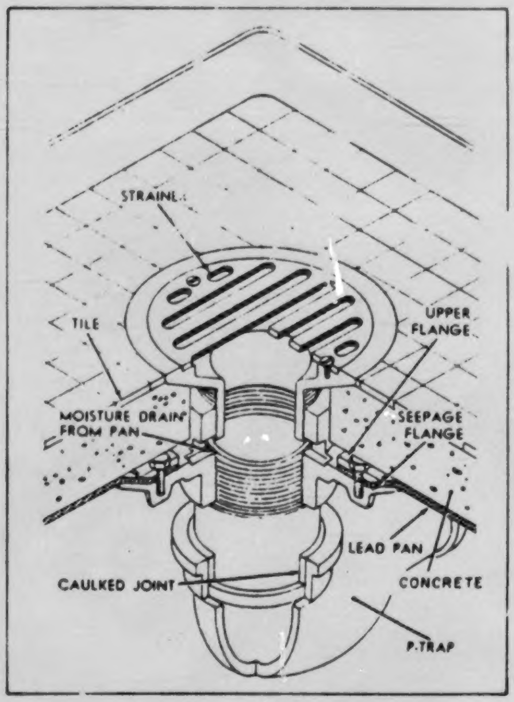


Figure 3-16. Shower drain showing lead pan.

The waste and vent lines for showers should be installed with a fall of 1/4 inch per foot run. However, waste pipes 3 inches in diameter or larger for showers may be installed with only 1/8-inch fall per foot.

Shower wastes seldom cause trouble, since they have relatively clear water flowing through them. The primary problem is the removal of hair, which is usually caught by the strainer in the shower drain, as shown in figure 3-15. The diameter of the waste pipe used for a single shower should be 2 inches. Cast-iron pipe and fittings are used when the piping is to run under a concrete floor.

The most important requirement in a shower installation is the waterproofing of the walls and floors. Walls are less of a problem than floors, because they are subject only to the splashing of water and do not have water standing or collecting on them. Careful installation of tile or other impervious material with waterproof cement generally suffices to provide a waterproof wall installation. In the installation of the floor, it is necessary to provide a waterproof subbase under the shower floor, or water standing on the floor will gradually seep through it and cause leaks. The installation of one type of shower drain is illustrated in figure 3-16. This drain is constructed with a lead pan under the shower floor to guard against water seepage.

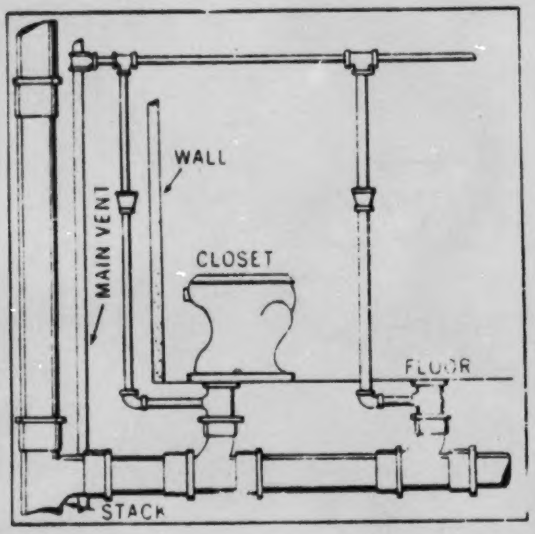


Figure 3-17. Battery of water closets individually vented.

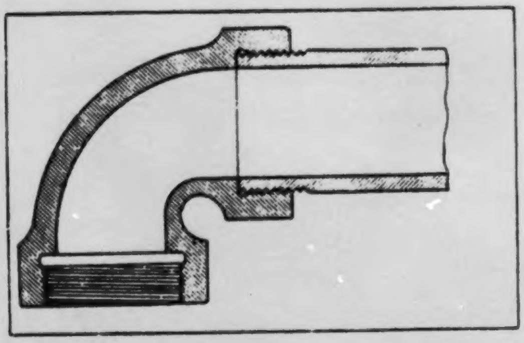


Figure 3-19. Recessed fitting.

To install this type of shower drain, first rough in the general outline of the shower stall to provide a solid base of subflooring or plywood on which the shower lead pan will rest. This flooring is necessary because the lead pan is soft and pliable; and if it is not supported properly, it will sag under the weight of the tile or other shower floor material and thereby cause a leak. After you check the flooring for adequate support, inspect the rough-in of the P-trap underneath the flooring to see that the outlet is in the desired position.

Next, construct a lead pan by using a solid sheet of lead approximately 6 to 8 inches larger than the size of the shower floor. The 6 to 8 inches of additional lead is used to form up the walls. This type construction prevents seepage around the base of the shower. Coat both sides of the lead pan near the drain hole with an appropriate waterproofing compound and place the pan on the shower floor. The pan should rest firmly on the shower floor as well as on the seepage flange. Now, place the upper flange over the lead pan directly above the seepage flange and bolt it to the seepage flange to form a watertight joint between the shower waste and the shower pan. Finally, screw the strainer of the shower drain into the seepage flange to the desired height. The installation is completed by laying concrete in the shower and finishing the floor with tile.

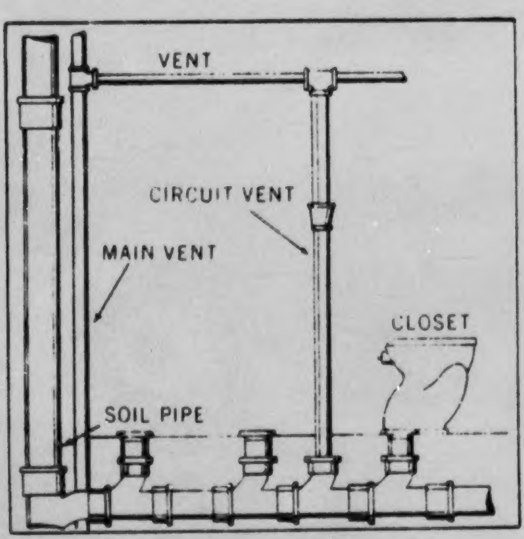


Figure 3-18. Circuit venting for a battery of water closets.

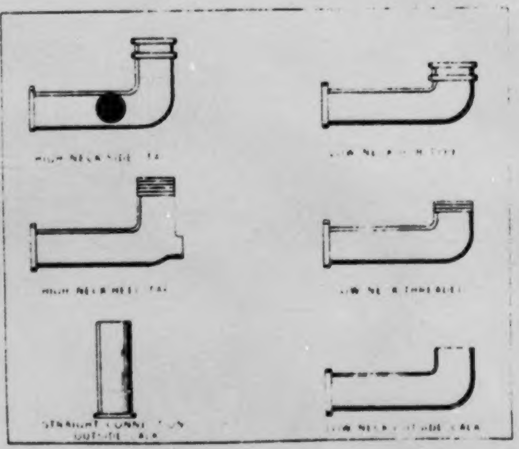


Figure 3-20. Types of closet bends.

The horizontal waste branch lines for tubs or shower rooms should be supported with metal hangers or supports when they are not braced otherwise by the building framework. A hanger should be installed as close as possible to a drum trap to support the weight of the trap and maintain the waste line at the proper angle for drainage. Metal hangers or supports should be made of the same type of material as the pipe to which they are attached. This prevents corrosive action of the metal parts, which is the result of electrolysis between dissimilar metals.

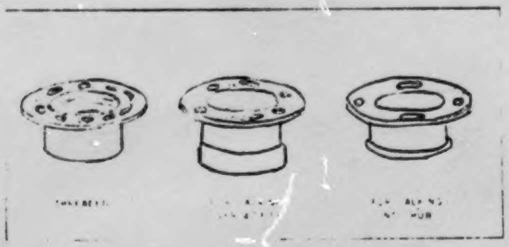


Figure 3-21. Closet bend floor flanges.

**Exercises (233):**

1. How much fall per foot is required for shower waste and vent lines under 3 inches in size?

2. What size waste pipe should be used for an individual shower?

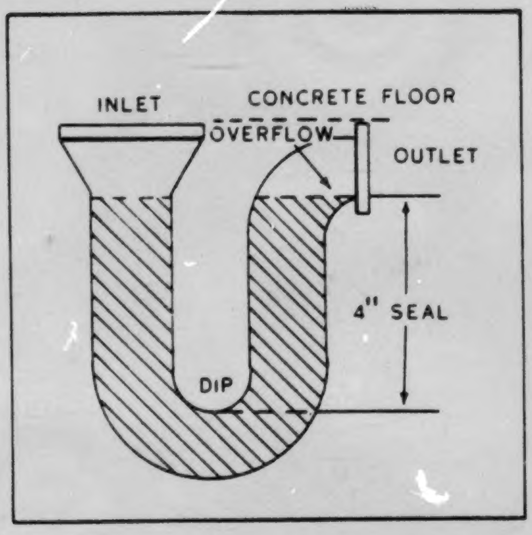

INLET
CONCRETE FLOOR
OVERFLOW
OUTLET
4" SEAL
DIP

Figure 3-23. P-trap with deep seal.

3. What is the most important factor to consider when installing a shower?

4. Why should supports, hangers, and pipes be made of the same type of material?

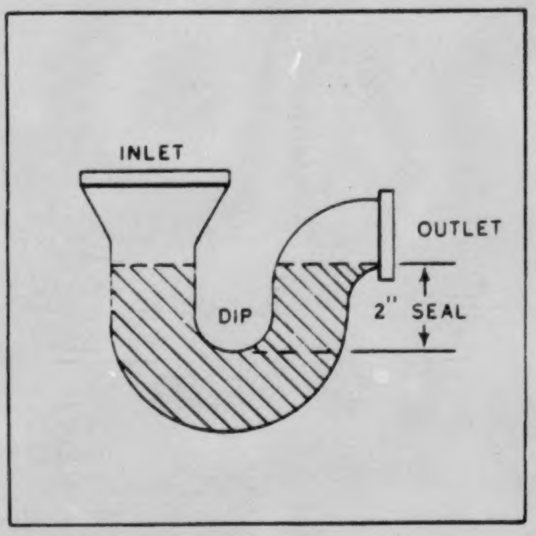

INLET
OUTLET
DIP
2" SEAL

Figure 3-22. P-trap with common seal.

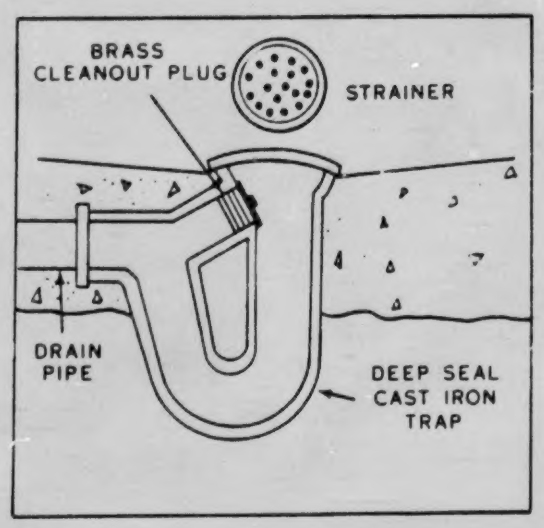

BRASS
CLEANOUT PLUG
STRAINER
DRAIN
PIPE
DEEP SEAL
CAST IRON
TRAP

Figure 3-24. Drain with a cleanout plug.

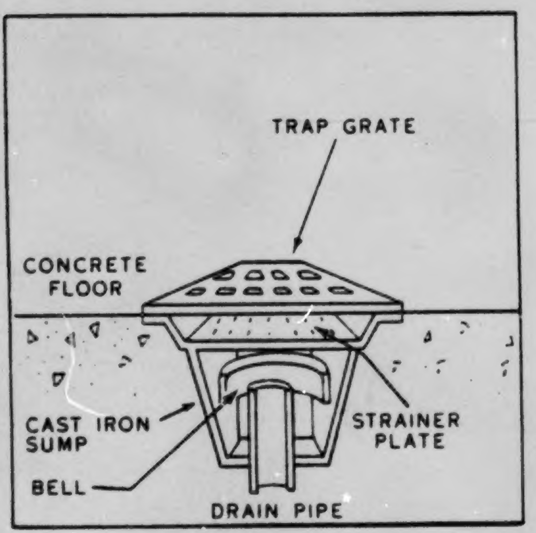


Figure 3-25 Sump type floor drain.

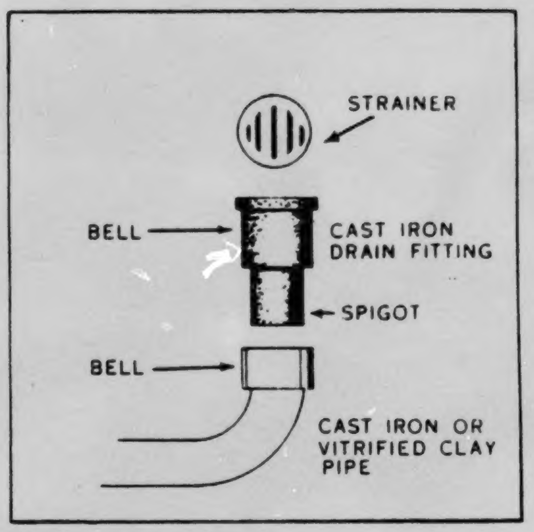


Figure 3-27. Outside storm drain fitting.

## 3-4. Waste Rough-In for Water Closets

You should now be able to rough-in waste lines for urinals and for bathtubs and showers. Adding to the knowledge you have gained thus far, you can readily learn how to rough-in waste lines for water closets, as the method is similar to the procedures you have just learned.

The most important of all modern sanitary fixtures is the water closet. The health of the occupants in any building depends upon the proper installation and maintenance of them.

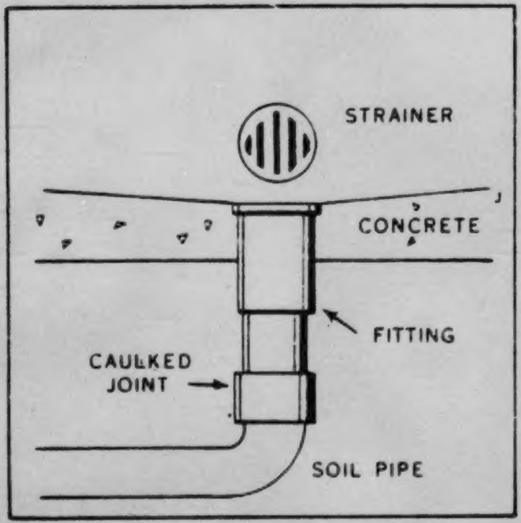


Figure 3-26. Outside storm sewer drain.

**234. Select true statements concerning water closet drains and vents.**

**Water Closet Drainage and Vent Methods.** Usually, the location of a water closet in a structure governs the location of the soil stack. The plumbing system is normally designed so that the soil branches discharge into the soil stack with a minimum horizontal pipe run. Additional venting is not required when the water closet discharges directly into a soil stack through a closet bend, as shown in figure 3-14.

Whenever a battery of water closets discharges into a horizontal soil pipe, they may be individually vented, as shown in figure 3-17, or the closets may be vented into a circuit, as shown in figure 3-18. Remember, you cannot vent over eight closets in one circuit.

Buildings of different types that are constructed on concrete slab floors use a closet bend imbedded in the concrete floor to which the water closet is attached. In this type of construction, the closet does not have to be vented. However, where a battery of water closets is installed, individual or circuit vents should be used.

**Exercises (234):**

Mark the true statements by placing a T in the appropriate spaces.

____ 1. Usually, the water closet governs the location of the soil stack.

____ 2. A battery of 6 water closets can be circuit vented.

____ 3. Buildings with slab floors use a closet bend imbedded in the floor to connect the water closets.

____ 4. Additional venting is always required for water closets.

**235. From a list of materials choose those that can be used on water closet drains and vents.**

**Materials Used for Water Closet Vents and Drains.** Soil branch lines may be constructed of cast-iron, galvanized wrought-iron, or copper-iron soil pipe and fittings. Cast-iron pipes and fittings are used when soil and branch lines are installed underground or in concrete floors. Threaded galvanized wrought-iron pipe may be used for soil stacks or branch lines when the stack or branch is not concealed in a wall or floor. Special cast-iron recessed fittings, like the one shown in figure 3-19, are used with threaded wrought-iron pipe. The recess of the female thread creates a smooth interior at the joint, which in turn lessens the probability of grease or solids causing a stoppage in the flow.

Copper is being used in more and more structures where highly corrosive conditions exist. The use of copper eliminates heavy tools and equipment required for threaded pipe or calked and leaded joints. A complete selection of brass fittings is available for use with copper soil pipes.

The smallest cast-iron pipe that should be used for a soil branch is 4 inches. When copper is used, 3-inch pipe can be used because of the smooth interior of the pipe and fittings.

Plastic pipe is being used quite frequently in modern-day construction. It is economical and easily installed. The smallest size of plastic pipe that can be used on a soil branch is 3 inches. Like copper, it has a smooth interior and will serve the same purpose as 4-inch cast iron. Be sure to always use the same type of pipe and fittings; some plastics have different characteristics and will not bond properly with each other.

When installing a plastic system it may be beneficial to cut, ream, and lay the system out before bonding. This way you can check for alinement, proper position, and grade. When you have the system installed like you want it, you can mark the pipe and fittings to aid in realinement. Next, take it apart and clean the ends of the pipe with the recommended solvent cleaner. Then, it is time to apply the solvent cement to the pipe and fittings. You should apply the solvent cement to only one joint at a time, because it seizes very fast. After applying the solvent cement, offset the marks on the pipe and fittings approximately one-fourth turn, insert the pipe in the fitting, and aline the marks. This insures a solid weld by removing air bubbles.

The horizontal soil branch lines should be secured with hangers to support the weight of the pipe and to maintain a fall of 1/4 inch per foot.

**Exercises (235):**

1. Choose the materials that can be used on water closet drains and vents.
   a. Virtrified clay.
   b. Plastic.
   c. Cast iron.
   d. Asbestos cement.
   e. Copper.
   f. Galvanized wrought iron.

2. Why should you always use the same type of plastic and fittings?

**236. Provided situations pertaining to the assembly of water closet drains and vents, mark the correct statements.**

**Assembly of Water Closet Drains and Vents.** Most plumbing systems are laid out so that the closet bend discharges directly into the soil stack. When the joists and flooring are installed, you should get the rough-in measurement for the floor openings from the manufacturer's specification sheets and begin the installation. Be sure the measurements allow for the finished wall line. After the openings are made, install and calk the closet bend into the soil stack. You should do this operation when the stack is fabricated because of the shortage of working space for pouring the lead into the joints under the floor.

Water closets are installed on a closet bend floor flange, sometimes just called a flanged collar, which is attached to a portion of pipe referred to as a closet bend. Closet bends are commonly made of cast-iron soil pipe and are available in low- and high-neck designs with right, left, top, or heel tappings. Various types of closet bends are shown in figure 3-20.

Closet bend floor flanges, of which three types are shown in figure 3-21, are usually made of cast brass or cast iron and may be of the threaded or slip type. Threaded flanges are tapped with a 4-inch pipe thread. Slip type flanges are used for calking into the hub end of a closet bend or for calking over a 4-inch soil pipe.

**Exercises (236):**

Mark the correct statements by placing a checkmark (√) in spaces provided.

____ 1. Rough-in measurements should be taken from the manufacturer's specification sheets.
____ 2. Rough-in measurements should include the finished wall line.
____ 3. Water closets are installed on closet couplings.

____ 4. Slip type flanges are used for calking into the hub end of a closet bend.

### 3-5. Waste Rough-In for Floor and Roof Drains

Now that we have discussed waste rough-in for most of the plumbing fixtures installed in a building, let's complete this waste rough-in for floor and roof drains.

Floor and roof drains are used to carry away contaminated water to either a sanitary sewer or a storm sewer. Sanitary sewage very seldom passes through these drains unless fixtures that dispose of these wastes overflow.

**237. Distinguish between the correct and incorrect statements pertaining to floor drains.**

**Floor Drains.** Floor drains may be installed in the floor of a work area which requires that the floor be washed down regularly for cleanliness. An example of this is the kitchen or dishwashing area in a dining hall. It may also be necessary to install a floor drain near the urinals in a latrine. Urinals sometimes overflow because of waste pipe stoppages or faulty flushing valves. The floor drain will carry off the water and prevent flooding of the floors. Floor drains are also used in basement floors to drain off water which collects from seepage, and in upper floors to prevent damage to the ceilings in the rooms below.

*Types of floor drains.* Floor drains are generally divided into two groups: those that are designed with a water seal and those that are not. Drains with a water seal are normally used with sanitary sewers. They allow waste to flow into the sewer but prevent sewer gas and odors from coming up into the building. Drains without a water seal are used with storm sewers, because there is no danger of the formation of sewer gases.

Floor drains used with sanitary sewers are considered to be plumbing fixtures, and like fixtures they must have a trap. The P-trap is the most common type used for these floor drains. P-trap drains are of two kinds: those with a common seal, as shown in figure 3-22, and those with a deep seal, as shown in figure 3-23. The common seal trap has a liquid seal of 2 inches, and the deep seal trap has a 4-inch seal. The common seal trap is used in those places where it can be vented. The deep seal trap is used in situations where the trap cannot be vented. The deep seal trap may be used in floor drains that are not used very often. It offers a greater resistance to siphoning, and when it is not in regular use, it does not lose its seal as quickly as the common seal P-trap.

A P-trap type of floor drain assembly that has a cleanout plug concealed under the strainer plate is illustrated in figure 3-24. This type of trap is used in concrete floors when it is impossible to make other provisions for cleaning the waste line and trap.

Another type of floor drain is the sump or cesspool, shown in figure 3-25. This drain is designed with a bell trap instead of a P-trap. As you can see, the bell is attached to the strainer plate. The position of the bell over the outlet pipe forms the trap. The sump catches a large percentage of the silt and dirt that runs into it with the water. The strainer plate with the bell can be removed to clean the sump and trap.

A drain without any type of seal is shown in figure 3-26. This drain is used only for draining water into storm sewers, where sewer gas and odors are not a problem.

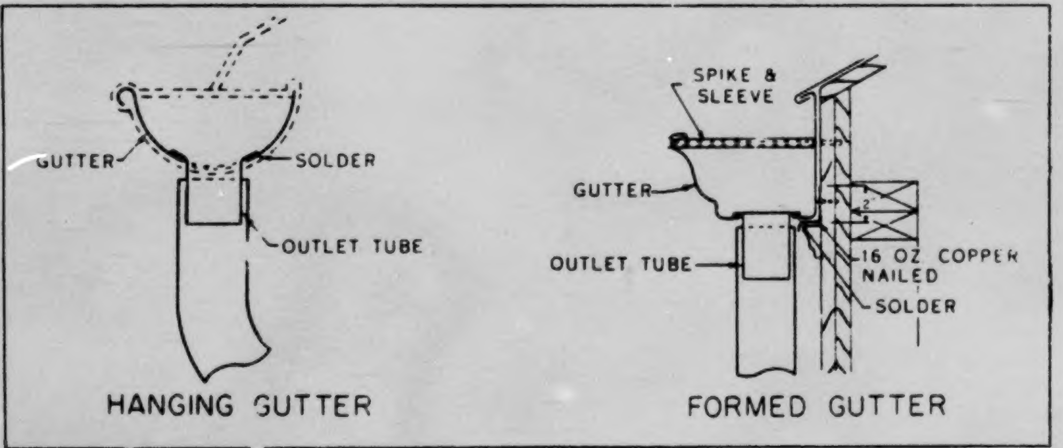
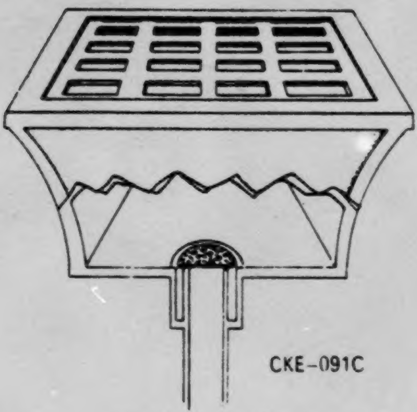
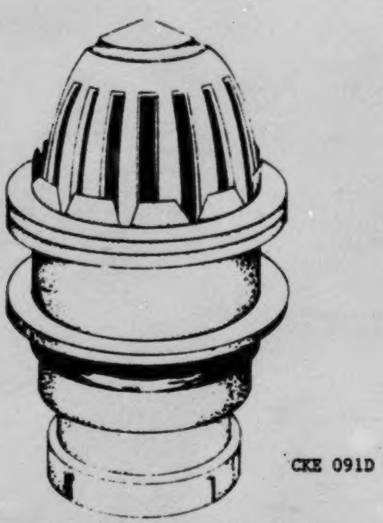


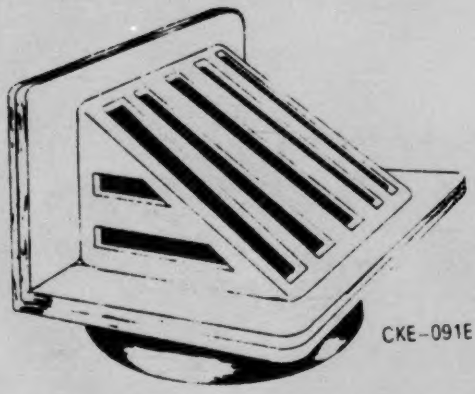
Figure 3-28. Hanging and formed gutters.



FLAT STRAINER



MUSHROOM STRAINER



SLOPED DRAIN

Figure 3-29. Three types of roof drain strainers.

*Installation of floor drains.* The smallest diameter of pipe used for waste lines for floor drains is 2 inches. The waste pipe should be installed with a fall of 1/4 inch per foot. However, waste pipes with a diameter of 3 inches or larger may have a fall of 1/8 inch per foot. The traps and pipes that are imbedded in soil or concrete should be constructed of cast-iron pipe and drainage fittings. The bell-and-spigot joints should be calked and leaded, and the threaded joints must be tightened to make a watertight and gastight seal. When a concrete floor is installed, the rough-in pipes and traps must be secured and anchored to prevent them from shifting or moving as the concrete is poured.

Whenever floor drains are to be installed in the upper floors of a multistory building, the floors must be waterproof to prevent damage to the ceilings in the lower rooms. This can be insured by installing a lead or copper pan beneath the concrete to direct water that seeps through the floor into drains similar to the drain shown in figure 3-16. The floor drain in this figure shows how a lead pan may be installed in a shower floor. Sometimes it is permissible for the lead pan to extend only 3 or 4 feet from the drain rather than cover the entire floor as is required in shower rooms. The specification sheet for the job should indicate the size of the pan required for the drain.

You may have to install a floor drain outside a building to serve, for example, a vehicle or equipment washrack. Such a drain is never connected to a sanitary sewer because of the large amounts of dirt and mud that enter it. The waste pipes for this type of drain are connected to a storm sewer. In all cases, permission must be obtained from the base engineering section before any connections are made to the storm mains. Cast-iron soil pipe or vitrified clay pipe and fittings may be used in the construction of these drainage lines. Since silt, dirt, vegetable matter, and other similar foreign substances are carried by the liquids into the sewer, the sewer pipe should be at least 4 inches in diameter and have a fall of 1/4 inch per foot along the line. Four- and 6-inch cast-iron drain fittings, like the one shown in figure 3-27, may be used to fabricate the drain. The spigot end of the pipe can be calked into the vitrified pipe, and the bell end will accommodate a cast-iron strainer. Usually, storm drains do not have any kind of seal.

**Exercises (237):**

Distinguish between the correct and incorrect statements by placing a C in the spaces provided for those that are correct and an I for those that are incorrect.

____ 1. A floor drain should always be located near urinals.
____ 2. Floor drains are divided into three groups.
____ 3. Floor drains are not considered as plumbing fixtures.

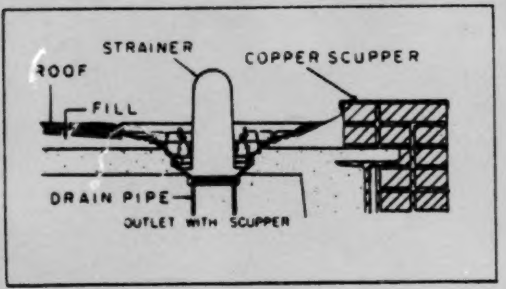


Figure 3-30. Roof drain installation.

____ 4. A deep seal P-trap has a water seal of 4 inches.
____ 5. A common seal trap is used in situations where the trap cannot be vented.
____ 6. The smallest diameter of pipe that can be used on floor drains is 2 inches.
____ 7. You should never connect a vehicle washrack drain to the sanitary sewer.

**238. Answer pertinent questions related to the purpose and installation of roof drains.**

**Roof Drains.** Roof drains installed on buildings to drain the water from the roofs prevent water from seeping into the building. A satisfactory roof drainage system drains water quickly from the roof and prevents the formation of pockets in which snow and ice may collect. Roofs, flashings, and valleys should shed water directly and speedily to gutters or drains and to the ground or sewer.

*Types of roof drains.* The water that accumulates on a roof may be removed by various methods. It may be allowed to run off and drip from projecting eaves or drain in gutters along the eaves. The water may also be collected by roof drains and carried to the sewer by interior drain pipes. The latter method is the most satisfactory, especially in cold climates where gutters and downspouts may clog up with ice and snow. This condition may cause water to back up above the flashing and find its way into the building. Inside drain pipes can be run down side columns, or installed in partitions or in exterior walls. In general, interior drain pipes receive sufficient heat from the building to keep them free of ice and snow. Figure 3-28 shows two types of gutters—the hanging gutter and the formed gutter—each of which can be used to collect the water at the eaves. There are three basic types of roof drain strainers: flat, mushroom, and sloped. (See fig. 3-29.)

Flat strainers are used on roofs that are utilized as sun decks, parking lots, or roof gardens.

Mushroom strainers provide a large elevated area of drainage for flat roofs, where there is a possibility of leaves and other debris accumulating.

Sloped strainers are used when the drain is located in a patched roof or where the drain is placed at the corner of the roof.

*Installation of roof drains.* When installing roof drains, you must take care to position them at the lowest roof level so that water will readily drain into them. Cut out the opening for the drain and construct the brackets or hangers that are necessary to hold the drain in a rigid position. If the drain is to be imbedded in a concrete roof, it must be installed during the time the concrete is poured. Figure 3-30 illustrates a roof drain installation.

The size of the roof drain is based on the amount of rainfall or snow, and the size of the area to be drained. The open area of the strainer should be 1½ to 2 times the area of the pipe to which it is connected.

Gutters and gutter outlets should be properly designed to carry off the water. When the outlets are inadequate, the water either backs up behind the flashing and leaks into the building or spills over the side of the gutter and stains the outside walls. The gutters should have enough pitch to run off the water and be shallow enough so that they will not hold a heavy load. Deep and flat gutters may fill with snow and ice, and the thrust of the freezing water may cause breaks and leaks.

When interior drains are used, some provision should be made for an overflow. If an overflow is not provided, an outlet stoppage will cause an overflow of water into the building. Drain outlets should be fitted with guards to prevent leaves, twigs, sticks, paper, or other debris from clogging them. Improper strainers often do more harm than good by impeding the drainage, or by collapsing and causing the accumulated debris to jam the drain pipes.

**Exercises (238):**

1. What are the basic types of roof drain strainers?

2. How much larger should the roof drain strainer be than the drain pipe to which it connects?

3. What additional provisions should be made when interior drains are used for roofs?

# Measuring, Cutting, Threading, and Assembling Pipe

CUTTING AND assembling pipe is very important, because the plumbing pipe connections must have a gastight and watertight seal in order for the plumbing system to operate satisfactorily. You must learn to cut, calk, and thread pipe correctly, since you will be performing these tasks daily in your work. You must also be very safety conscious as you do these tasks in order to prevent accidents and fires. Since the metal slivers from cutting or threading pipe are often razor sharp and your melting furnace is filled with gasoline, you are just one careless move away from getting hurt. This chapter discusses safety precautions, the methods of cutting and joining cast-iron pipe, and the methods of cutting and threading steel pipe.

## 4-1. Measuring, Cutting, and Assembling Cast-Iron Soil Pipe

There are several methods of cutting and assembling cast-iron soil pipe. The type of equipment your shop has will determine the method you will use to cut and assemble soil pipe.

**239. Identify the correct statements concerning measuring and cutting cast-iron soil pipe.**

**Cutting Cast-Iron Soil Pipe.** Before cutting any cast-iron soil pipe, you must know how to make measurements. Also, you need to know the cutting tools and methods of cutting cast-iron soil pipe.

*Measuring cast-iron soil pipe.* It is important that you learn how to locate the center of fittings. The center of a fitting is that point where the lines of flow through the fitting intersect each other, as shown in figure 4-1. In a drainage system, suppose you are going to join a 1/4-bend and a 1/8-bend fitting with a piece of soil pipe and the center-to-center measurement must be 36 inches. You can see that the piece of pipe will be less than 36 inches because the fittings will take up part of the overall measurement, as shown in figure 4-2.

If it is possible to place the two fittings together, as shown in figure 4-3, the measurement between the center marks on the fittings can then be subtracted from the overall measurement of 36 inches to arrive at the length of pipe required. A fast method for determining pipe length is to let a ruler do your figuring. Place the 36-inch mark of the ruler on the center mark of the fitting on the right, as shown in figure 4-4. The mark on the ruler which falls over the center mark of the fitting on the left then indicates the length to cut the pipe.

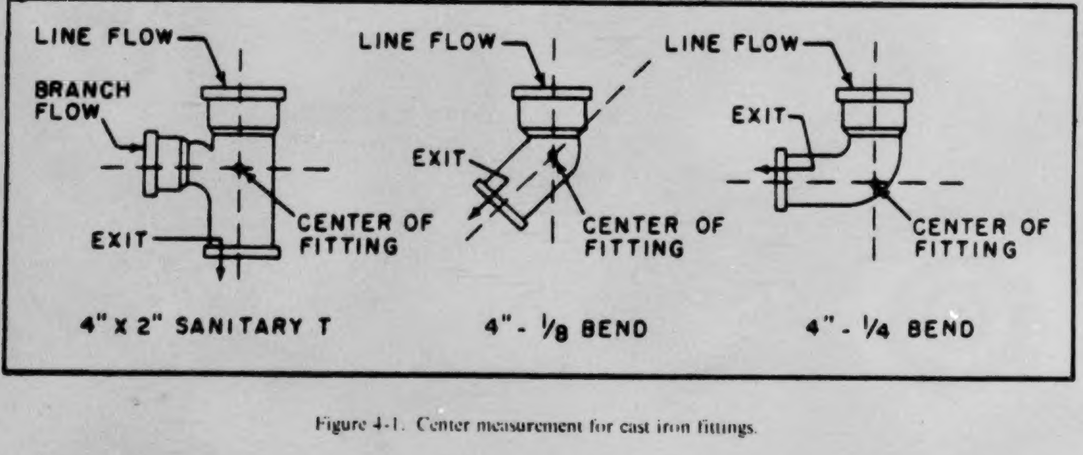


Figure 4-1. Center measurement for cast iron fittings.

114

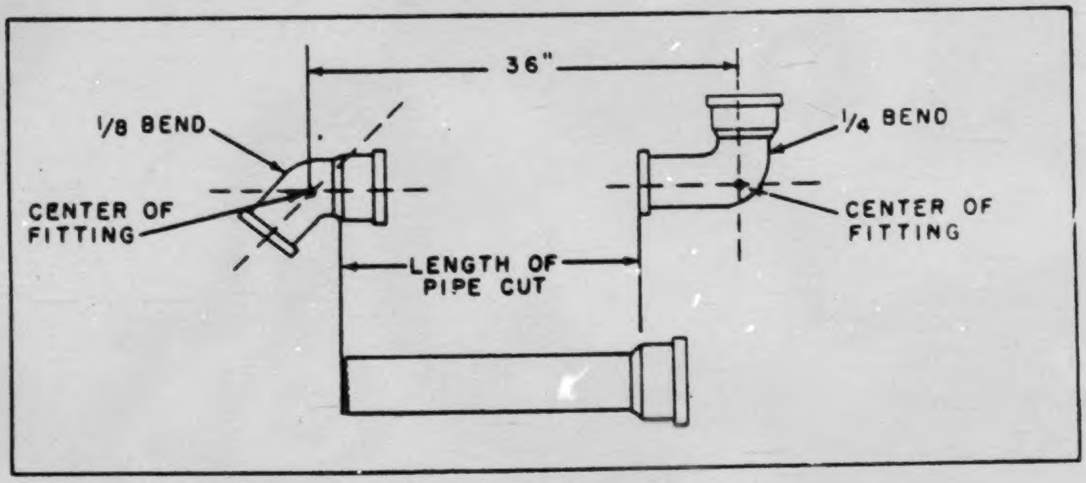

36"
1/8 BEND
1/4 BEND
CENTER OF FITTING
CENTER OF FITTING
LENGTH OF PIPE CUT

Figure 4-2. Determining the length of pipe.

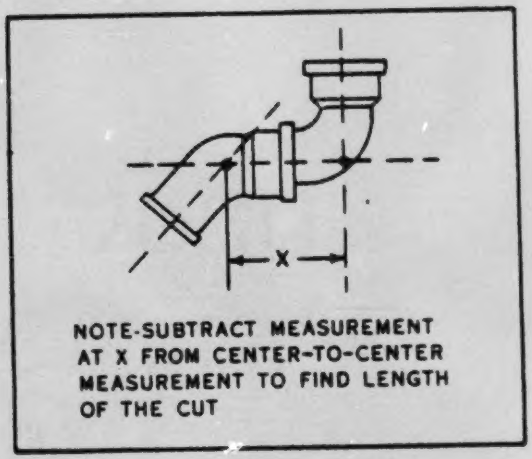

X
NOTE-SUBTRACT MEASUREMENT AT X FROM CENTER-TO-CENTER MEASUREMENT TO FIND LENGTH OF THE CUT

Figure 4-3. Using the subtraction method to compute pipe length.

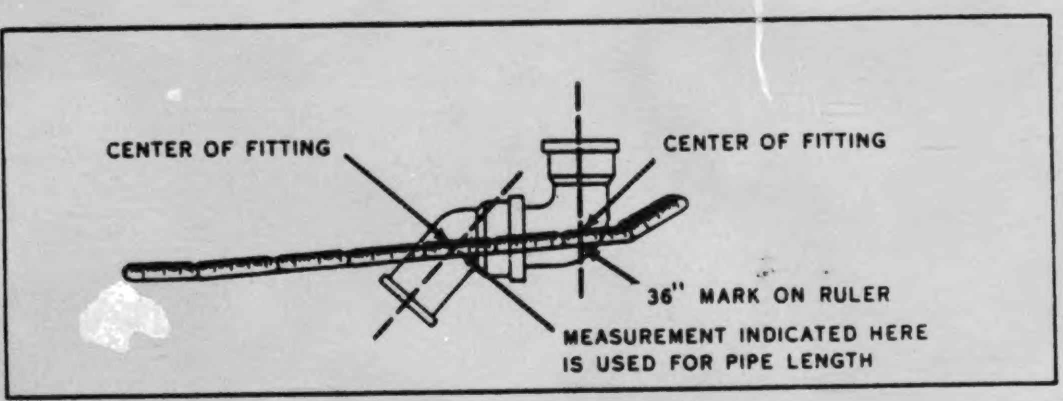

CENTER OF FITTING
CENTER OF FITTING
36" MARK ON RULER
MEASUREMENT INDICATED HERE IS USED FOR PIPE LENGTH

Figure 4-4. Using the ruler to compute pipe lengths.

115

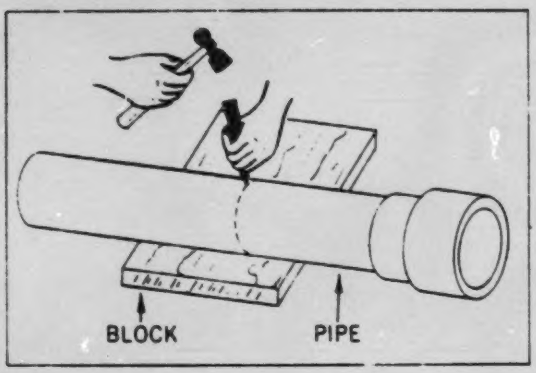


Figure 4-5. Cutting cast-iron pipe with a hammer and chisel.

*Cutting tools.* There are many different brands and types of tools for cutting cast-iron soil pipe. Shop tools may vary from base to base. Such tools as a hammer and chisel, the manual snap cutters, hydraulic snap cutters, manual chain cutters, pipe cutters, hacksaw, and adjustable wrench are used in plumbing operations.

*Cutting cast-iron soil pipe.* The oldest method of cutting cast-iron pipe on the job is the hammer and chisel method. You can also use this procedure to cut vitrified clay tile. To cut the pipe, first make a mark entirely around the pipe where the cut is to be made. This mark should be true and not ragged or rambling. When you are working inside or on a floor, use two blocks of wood, preferably 2 by 6 inches, to support the pipe so it will be level. This also keeps the pipe from shattering, as the wood absorbs the shock of the hammer blows. One block of wood should be positioned directly under the line of cut, as shown in figure 4-5. When you are working outside, you can use a mound of earth instead of the blocks of wood to support the pipe.

When you cut 4-inch cast-iron pipe, score the pipe around the chalkmark by lightly tapping a 1-inch cold chisel with a 16-ounce ball peen hammer. When you cut 2- or 3-inch cast-iron pipe, use a 3/4-inch cold chisel and a 16-ounce ball peen hammer. The taps should be light at first. Point the chisel toward the center of the pipe and move it around the line of cut in overlapping steps between successive blows. Continue to rotate the pipe and strike the cold chisel with increasingly heavier blows. Repeat these steps until the pipe breaks and separates at the line of cut. Be sure to protect your eyes and body from flying chips when you cut cast-iron pipe. Wear goggles, gloves, and a jacket with long sleeves. Remember, the brittleness of cast iron causes a rough edge on the pipe when it is broken. Be careful, because you may cut yourself if you contact the edge in the wrong way.

Sometimes cast-iron pipe is unserviceable because it is cracked. These cracks may be a result of rough handling during shipment or manufacture. Some of the cracks are so fine that they are called hairline cracks. They are difficult to see even when you are handling the pipe. For this reason, each length of soil pipe should be sounded with a hammer before and after you cut it. To sound the pipe, raise it clear of the supports and strike it lightly with a hammer. A clear, bell-like ring indicates that the pipe is not cracked and may be used. If the pipe has a dull sound, it is cracked and should be placed in scrap barrels or piles for salvage.

Figure 4-6 illustrates the use of the manual snap

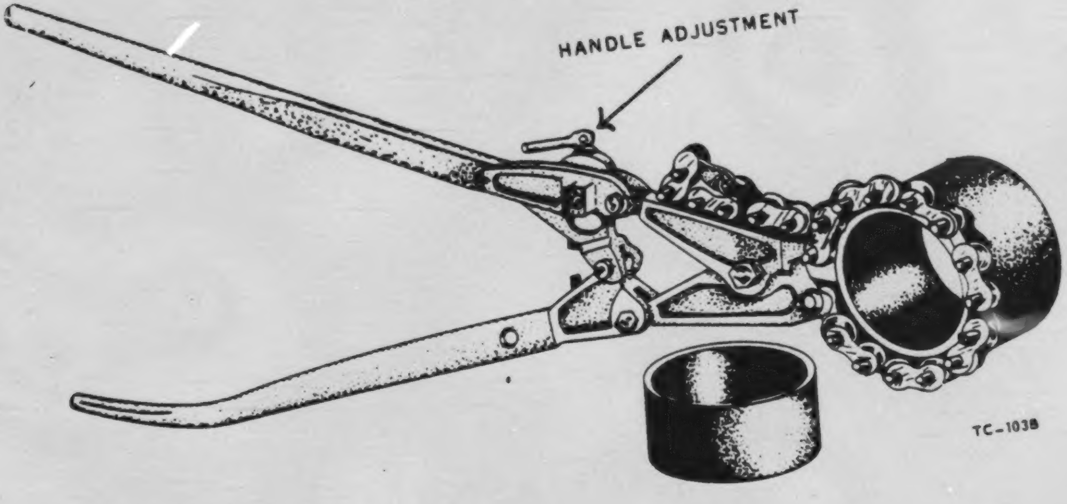


Figure 4-6. Manual snap cutter.

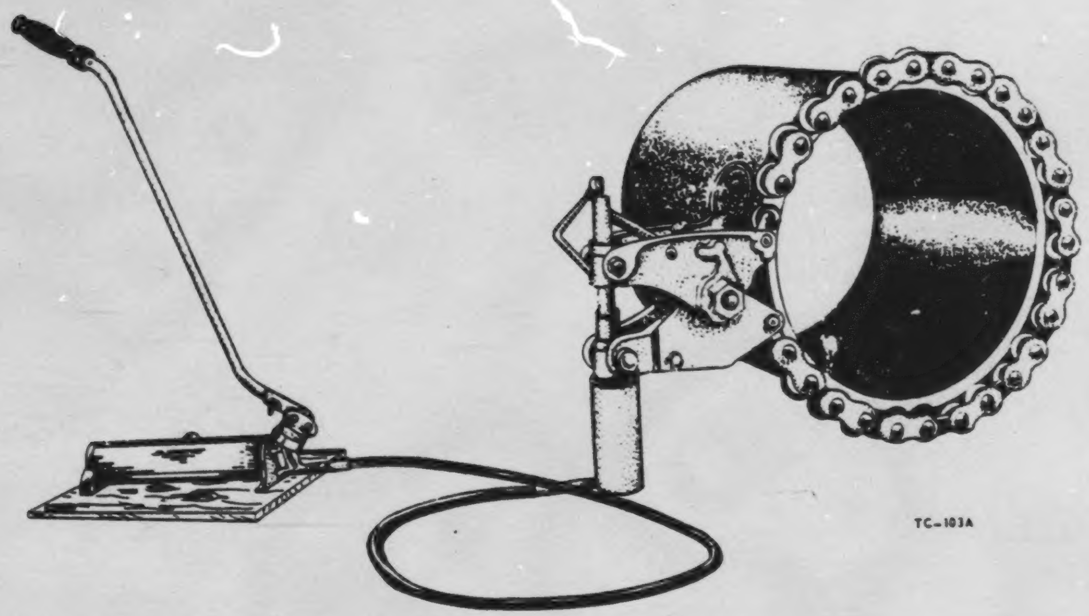


Figure 4-7. Hydraulic snap cutter.

cutter. After you have measured and marked your pipe, place the cutter into position and adjust the handle. Check the cutting chain to make sure it is properly alined before you attempt to make your cut.

The use of a hydraulic snap cutter is illustrated in figure 4-7. Its operation is simple and with no strain for the operator. Always aline the cutter chain before attempting to make your cut. Make sure to follow the procedure set forth by the manufacturer.

CAUTION: Keep onlookers a safe distance from your work area. Pipe which is put in motion by the snapping action may be dangerous to the onlookers.

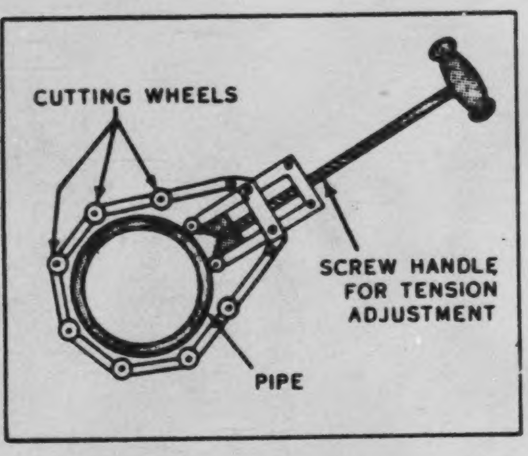


Figure 4-8. Chain type pipe cutter.

Figure 4-8 illustrates a chain type cutter, which operates very fast and produces clean-cut ends on pipe that is 4 inches in diameter or larger. To cut cast-iron soil pipe with the chain cutter, place the cutting chain around the pipe and adjust tension handle until the cutter is snug against the pipe. Rotate the cutter back and forth, slightly adjusting the tension with each pass until the pipe is cut.

Two-inch cast-iron pipe can be cut with a pipe cutter similar in design to the one used on galvanized or black pipe. These cutters are equipped with a cast-iron cutting wheel as compared to the conventional steel cutting wheel shown in figure 4-9.

Cast-iron soil pipe can also be cut with a hacksaw. This method is slow but produces a smooth, clean cut. Some plumbing shops are equipped with a power hacksaw, which is fast and makes smooth cuts when a blade designed for cast iron is used.

If you have to remove only 1 or 2 inches of metal from a length of cast-iron pipe, use a hacksaw and an adjustable wrench for this operation. If you try to cut the pipe with a hammer and cold chisel, you will probably break the pipe in the wrong place; and furthermore, the edge of the break would be very irregular. To cut 1 or 2 inches from the end of a pipe, cut a groove with the hacksaw around the pipe on the line of cut to a depth equal to one-half the wall thickness of the pipe. Now break away the section of the pipe to be removed with an adjustable wrench used as a lever, as shown in figure 4-10.

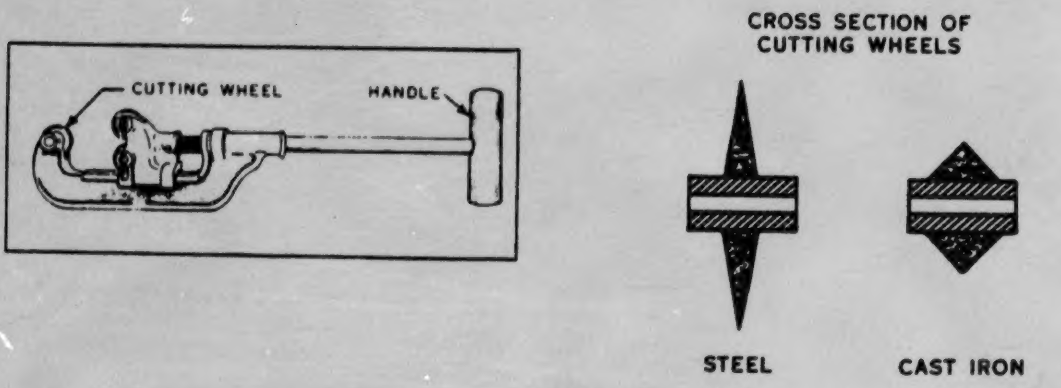


Figure 4-9. Regular pipe cutter.

Set the wrench opening so that the jaws of the wrench fit snugly over the wall thickness at the end of the pipe. Place the wrench over the end of the pipe wall in a position where the tip end of the wrench jaws are even with the outside edge of the groove on the line of cut. A downward pressure toward the pipe center is placed on the wrench handle until a chip breaks off. This process is repeated until all the material is broken loose and a clean cut is attained.

**Exercises (239):**

Identify the correct statements by placing a checkmark (√) in the appropriate blank.

____ 1. The center of a fitting is that point where the lines of flow through the fitting intersect.

____ 2. The oldest cutting tool for cast-iron soil pipe is the snap cutter.

____ 3. When cutting 2- or 3-inch cast iron with a cold chisel and ball peen hammer, the cold chisel should be 3/4 inch.

____ 4. When sounding cast-iron soil pipe with a hammer, a bell ring indicates the pipe is not cracked.

____ 5. Two-inch cast-iron soil pipe may be cut with a regular pipe cutter using a conventional steel cutting wheel.

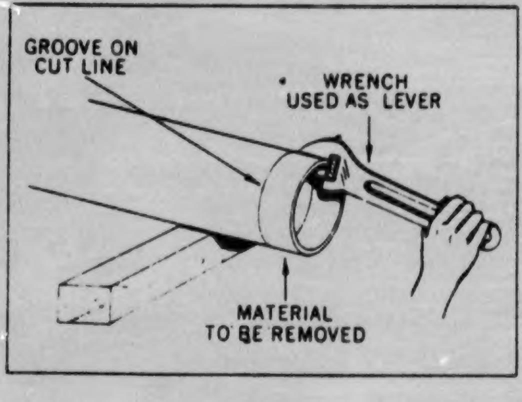


Figure 4-10. Cutting cast-iron pipe with a hacksaw and adjustable wrench.

**240. Given pertinent questions on assembling cast-iron soil pipe, supply brief answers.**

**Assembling Cast-Iron Soil Pipe.** Now that you know how to cut cast-iron pipe, let's find out how it is fabricated or joined together.

Joints are made in cast-iron, bell-and-spigot pipe by first packing oakum into the joint and then filling the remainder of the area around the hub with molten lead. The melting and handling of lead for calked joints tends to become commonplace procedure for the plumber who works with cast-iron pipe daily, but certain rules and safety precautions always must be followed. You must follow these rules and safety precautions to prevent accidents which may cause serious injury to yourself or your coworkers. If you are careless, you might cause a fire which could destroy the building in which you are working.

*Melting furnace.* You will be using a melting furnace for melting lead and keeping it at the proper temperature for pouring joints. A thermometer can show you when the lead is at the proper temperature. Place the thermometer in the lead, and when it indicates approximately 875° F., the lead is ready for pouring. If you do not have a thermometer, notice the color of the lead; when it turns a bluish tinge, it is ready for pouring. The melting furnace is a valuable plumbing tool, but you must be very cautious when you are using it.

The best and most efficient type of melting furnace uses liquefied petroleum gas as a fuel. This furnace consists of a burner and valve assembly which mounts directly on a portable propane gas tank. The tank is

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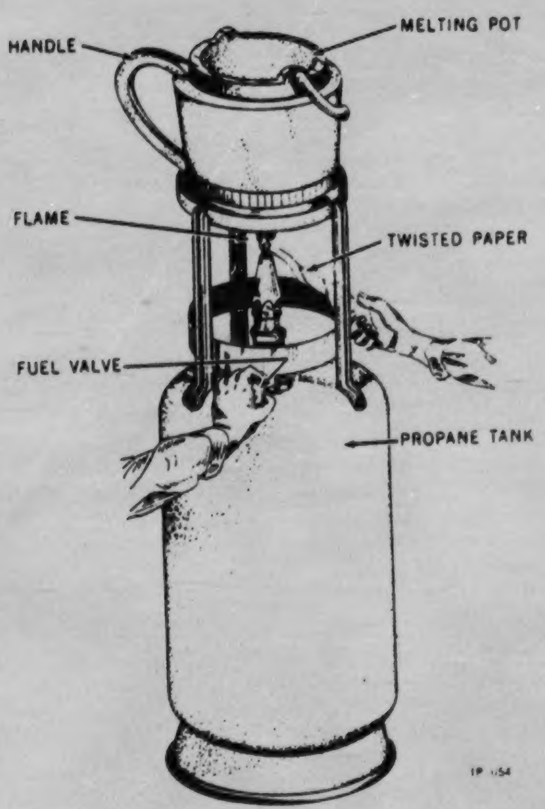

HANDLE
MELTING POT
FLAME
TWISTED PAPER
FUEL VALVE
PROPANE TANK
IP 054

Figure 4-11. Lighting a melting furnace.

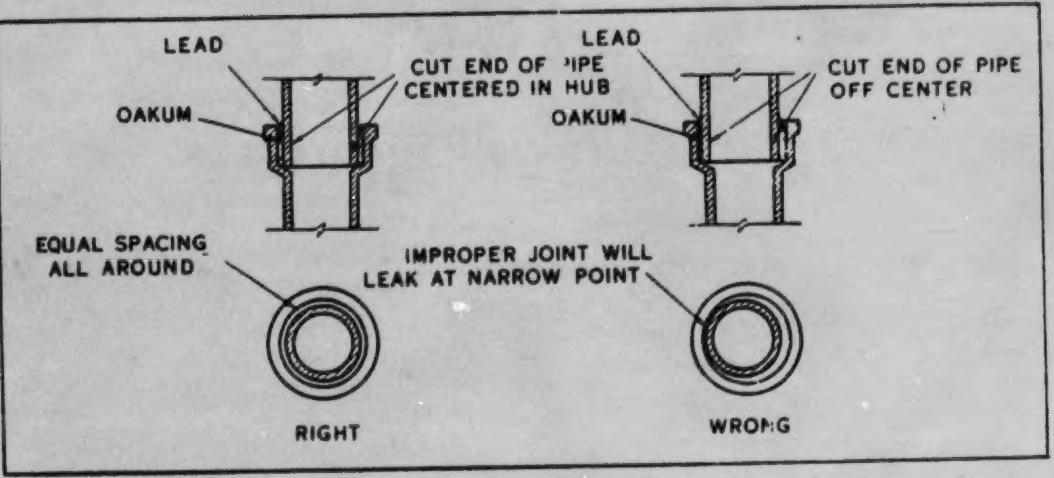

LEAD
CUT END OF PIPE CENTERED IN HUB
OAKUM
LEAD
CUT END OF PIPE OFF CENTER
OAKUM
EQUAL SPACING ALL AROUND
IMPROPER JOINT WILL LEAK AT NARROW POINT
RIGHT
WRONG

Figure 4-12. Centering a bell-and-spigot joint.

detachable and can be recharged with fuel. A propane furnace lights instantly and burns with a high-temperature blue flame. This furnace should not be subjected to rough treatment since there is always the danger of an explosion from leakage of gas at the connections and valves. A thorough inspection for leaks should be made before lighting the furnace. To light the furnace, fold or twist tightly a length of paper, light one end, and place under the orifice of the burner assembly. (See fig. 4-11.) Carefully open the fuel-regulating valve until the burner lights. If the valve is opened too much or too rapidly, the pressure of the escaping gas may extinguish the lighter flame. If this should happen, close the fuel valve immediately, and then relight the paper before reopening the valve.

A safe worker will always wear asbestos gloves and face shield for protection when lighting a furnace, as there is the possibility of receiving burns from a puff or flame or small explosion as the fuel ignites.

Place one or two ingots or cakes of lead in the melting pot, and gradually melt the lead. If the lead reaches a cherry-red color, it is too hot for pouring, and the flame should be lowered.

*Pouring vertical lead joints.* Joints in vertical piping are usually the easiest to make and require fewer tools than joints in horizontal piping. You do not need a joint runner to make a joint in vertical piping, because the rim of the bell forms an open receptacle for receiving the lead. Inspect the bell-and-spigot ends of the pipes to be calked to make sure they are free of moisture. If the ends are wet, heat them with a torch until they are dry. Moisture in the joint will cause molten lead to spatter when it is poured, and you could burn yourself. Place the spigot end of the pipe into the bell of the pipe below. Aline the pipe so that an equal space between the pipe and the bell is maintained around the circumference of the joint, as shown in figure 4-12. A joint that is not properly centered is likely to leak on the side that has the least amount of oakum and lead.

Get the proper amount of oakum for the pipe diameter, as indicated in figure 4-13, and place the oakum into the joint and pack it handtight, as shown in figure 4-14. Tamp the oakum with a packing tool and hammer to within 3/4 to 1 inch of the top of the hub. Be sure to use pointed tools to fit the inside and outside edges of the joint. Compress the oakum thoroughly to form a solid bed for the lead and to prevent leakage of the joint. After the pipe is placed in service, the oakum will absorb moisture and expand to form a watertight and gastight seal.

After you pack the joint with oakum, you are ready to pour the lead. As the lead is heated, certain products of oxidation and other foreign matter may rise to the surface in the form of slag. This must be removed before the lead can be used to pour a joint. Do this by skimming the slag from the lead with a ladle. The ladle should be heated before you dip it into the lead to prevent a buildup of the lead on the ladle caused by rapid cooling.

After the slag is removed, obtain a plumber's ladle full of clean, molten lead from the melting pot, and pour the lead into the joint, as shown in figure 4-15, until it is even with the top of the hub.

It is a good practice to make the joint with one pouring. You will be able to estimate the amount of lead needed for a joint after you have poured lead into two or three. The average amounts of lead and oakum which are required for pipe joints are given in figure 4-13. These amounts should be allowed, in addition to the percent of waste, when you figure the material requirements for the job.

After you have poured lead into the joint, allow the lead to cool for a minute or two. Select an inside calking iron and place it against the inside edge of the lead projecting from the hub, as shown in figure 4-16. Strike the calking iron gently but firmly with an 8-ounce ball peen hammer to calk the lead down upon the oakum. Calk the lead all the way around on the inside first. This forces the lead to compress down and

| Pipe Size (inches) | Oakum or Equivalent (feet) | Lead (pounds) |
|---|---|---|
| 2 | 3 | 1 1/2 |
| 3 | 4 1/2 | 2 1/4 |
| 4 | 5 | 3 |
| 5 | 6 1/2 | 3 3/4 |
| 6 | 7 1/2 | 4 1/2 |
| 8 | 9 1/2 | 6 |
| 10 | 12 | 7 1/2 |
| NOTE: Allow at least 5 percent additional lead and oakum for waste. | | |

Figure 4-13. Material required for lead joints.

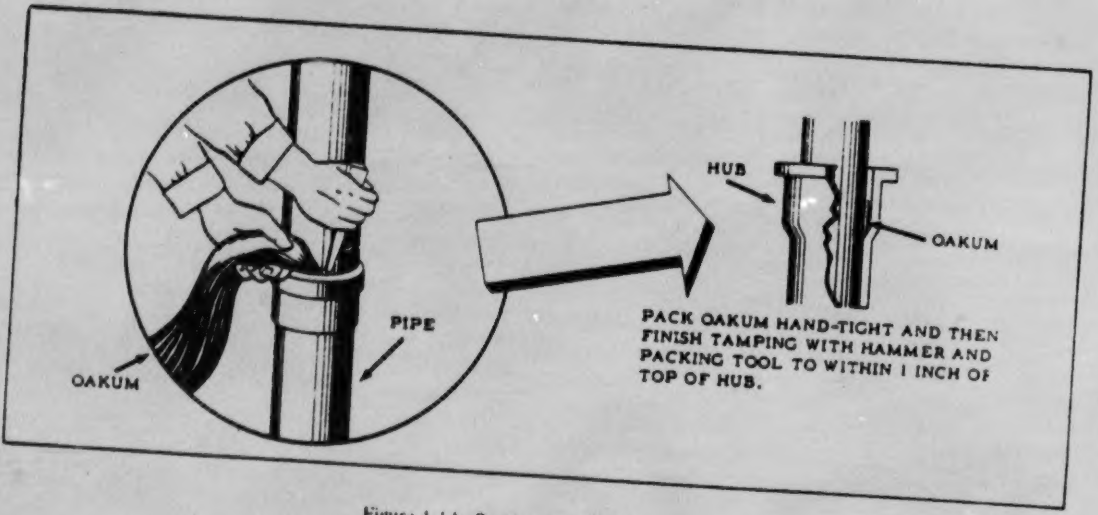

HUB
OAKUM
PIPE
OAKUM
PACK OAKUM HAND-TIGHT AND THEN FINISH TAMPING WITH HAMMER AND PACKING TOOL TO WITHIN 1 INCH OF TOP OF HUB.

Figure 4-14. Packing oakum into a joint.

expand into the groove in the hub. Next, use an outside calking iron and calk the lead next to the hub wall the same way the inside was calked. Do not strike the calking iron too hard, because the pressure may cause the hub to crack. A joint of pipe or a fitting that has a cracked bell must be replaced in order to have a watertight joint. More joints will leak as a result of the lead being too cold when poured than as a result of the calking procedure.

*Pouring horizontal lead joints.* To make a joint on horizontal piping, see that the pipe and fittings are properly supported and set for the desired grade or angle. Pack the hub with oakum in the same manner that you did to make a vertical pipe joint. An additional tool, called the asbestos joint runner, must be used when you make a horizontal joint to direct the molten lead into the joint, as shown in figure 4-17.

The joint runner has a spring tension clamp which holds it in place while the lead is poured into the joint. Push the joint runner up against the hub to form a tight dam for the molten lead. You can use a piece of oakum to prevent leakage where the ends of the runner come together at the clamp. Make the joint with one pour, and have the lead hot enough to insure a complete run around the joint before it cools; continue pouring the lead until the opening at the joint

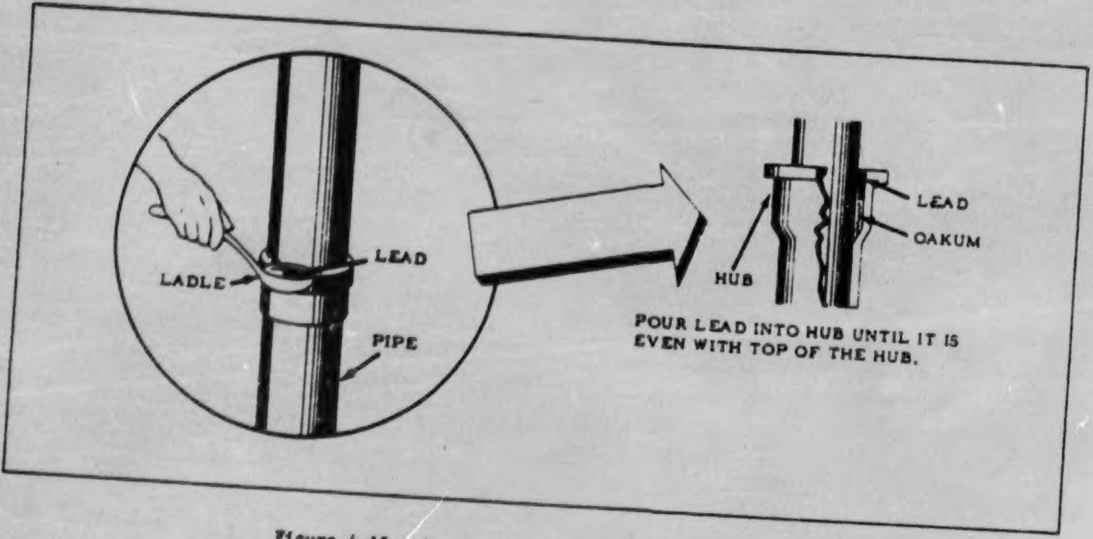
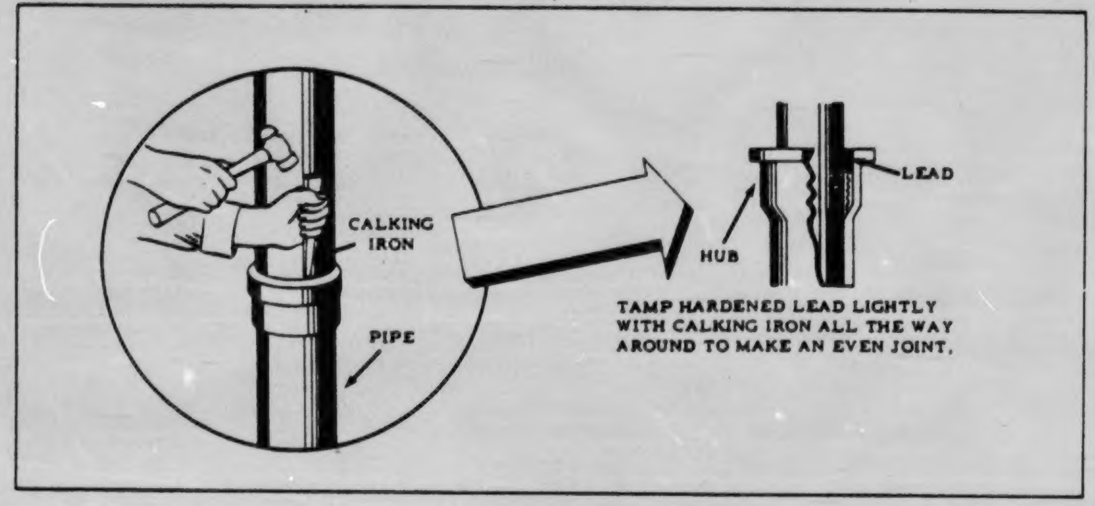
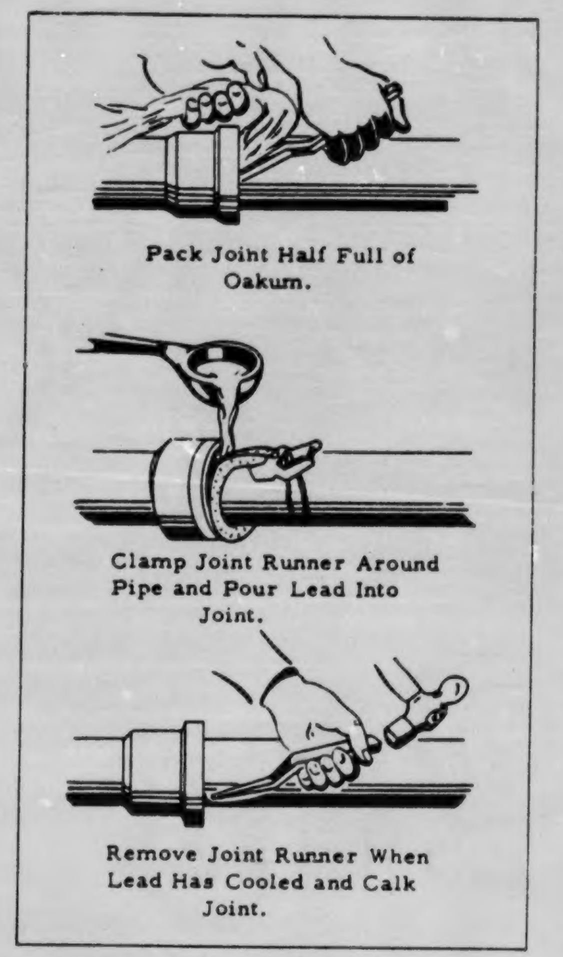

LEAD
LADLE
PIPE
LEAD
OAKUM
HUB
POUR LEAD INTO HUB UNTIL IT IS EVEN WITH TOP OF THE HUB.

Figure 4-15. Pouring hot lead into a joint.



TAMP HARDENED LEAD LIGHTLY WITH CALKING IRON ALL THE WAY AROUND TO MAKE AN EVEN JOINT.

Figure 4-16. Calking a lead joint.



Pack Joint Half Full of Oakum.

Clamp Joint Runner Around Pipe and Pour Lead Into Joint.

Remove Joint Runner When Lead Has Cooled and Calk Joint.

Figure 4-17. Making a joint in horizontal piping.

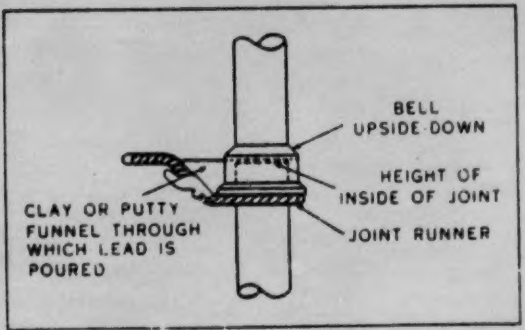


Figure 4-18. Pouring an upside-down joint.

runner clip is full. Allow the joint to cool and remove the asbestos joint runner. Use a cold chisel to cut away the excess lead formed by the pouring pocket and calk the joint, following the same procedure that you used on the vertical pipe joint.

*Pouring upside-down lead joints.* Sometimes, during the construction of a vent stack, you may have to pour lead into an upside-down joint. This type of joint is permissible when it is located above the drainage lines to the stack. The manner in which lead is poured into an upside-down joint is illustrated in figure 4-18. To force the lead to flow up into the hub, a clay or putty funnel is formed above the pouring opening in the asbestos joint runner. The funnel must be deep enough to raise the level of the lead inside the joint. You must exercise extreme caution when you pour this type of joint to prevent serious burns to yourself from splattering or falling lead. The putty or clay pouring funnel must be dry and free of moisture before the lead is poured to prevent blowout of the hot lead from steam. After the lead cools, the joint runner is removed, and the lead is calked in the same manner as that used for other joints.

Always keep in mind the dangers involved when working with, and handling, molten lead and heating devices. Take your time and plan your moves ahead to avoid accidents to yourself, your coworkers, and your equipment.

*Compression joints.* The compression joint uses hub-and-spigot pipe as does the lead-and-oakum joint. The major differences are the one-piece rubber gasket and the spigot end of the pipe and fitting, which is always plain, or without a bead. When the spigot end of the pipe or fitting is lubricated and pushed or drawn into the gasket hub, the joint is sealed by displacement and compession of the rubber gasket. The resultant joint is leakproof, rootproof, and pressureproof. It absorbs vibrations and can be deflected up to 5° without leakage or failure (see fig. 4-19). Figure 4-20 illustrates three methods of joining cast-iron soil pipe.

*No-hub joints.* The no-hub joint for cast-iron soil pipe supplements the lead-and-oakum and compression type bell-and-spigot joints by providing another and more compact arrangement. This system uses a one-piece neoprene gasket and a stainless steel shield and retaining clamps. The advantages of this system are that it permits joints to be made against a ceiling or in any limited-access area, and it is constructed using 2- and 3-inch sizes that will fit into 2 x 4 partitioned walls. Other advantages of this type of system are that installation is fast and efficient, and few tools are required.

When measuring no-hub pipe, measure the full length of the pipe (end to end). Spacers inside of the neoprene gasket where the fittings or pipe ends meet measure 3/32 inch; therefore, when fabricating a system, subtract 3/32 inch for each connection. Tightening the stainless steel retaining clamps is accomplished with a torque wrench. The desired degree of tightness is not less than 48 nor more than 60 inch-pounds of torque. Extra hangers are required for no-hub systems.

**Exercises (240):**

1. What color should molten lead be when you pour it into a joint?

2. What type melting furnace is the most efficient for melting lead?

3. How much space should be left in the hub for lead after the oakum is packed?

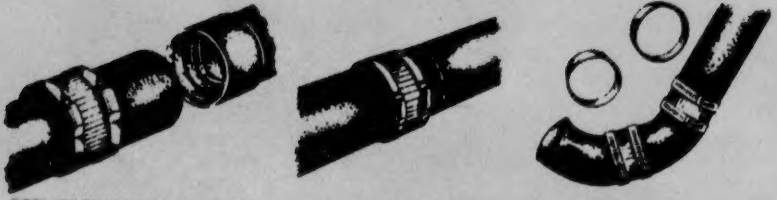
4. How much lead should be used in a 4-inch joint?

5. When you pour a horizontal joint, what additional tool is required?

6. How many degrees can compression joints be deflected?

## 4-2. Cutting, Reaming, and Threading Steel Pipe Manually

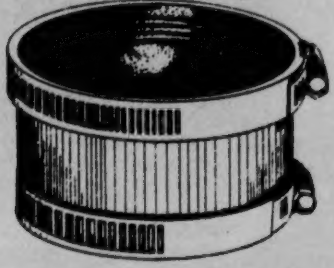
Although most shops have modern power tools, there are still some small jobs that have to be done manually.

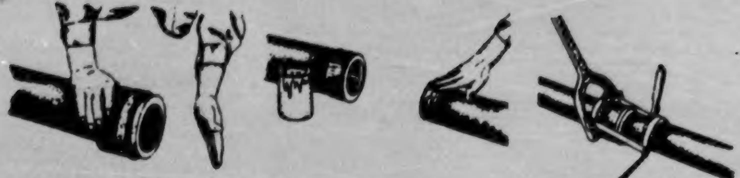


PIPES ARE POSITIONED BY SEPERATOR RING IN GASKET

CLAMP IS SLID OVER GASKET AND TIGHTENED

COMPLETED JOINT





NEOPRENE GASKET IS INSERTED INTO CLEANED HUB

LUBRICANT IS APPLIED TO SPIGOT END

PIPES ARE JOINED WITH PULLING TOOL

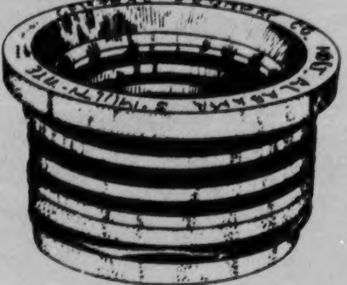


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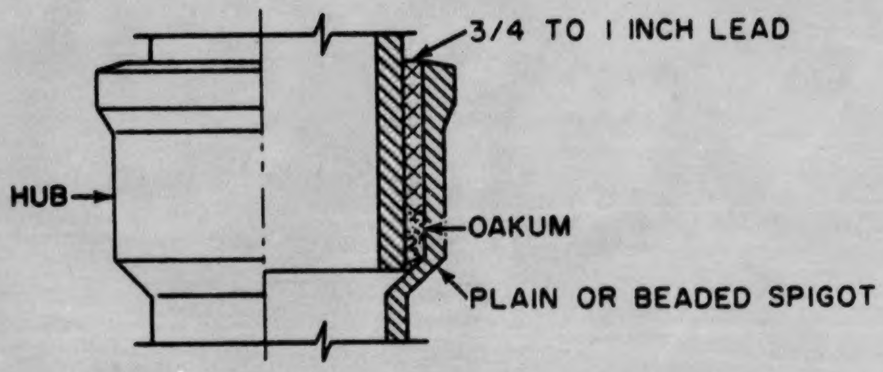
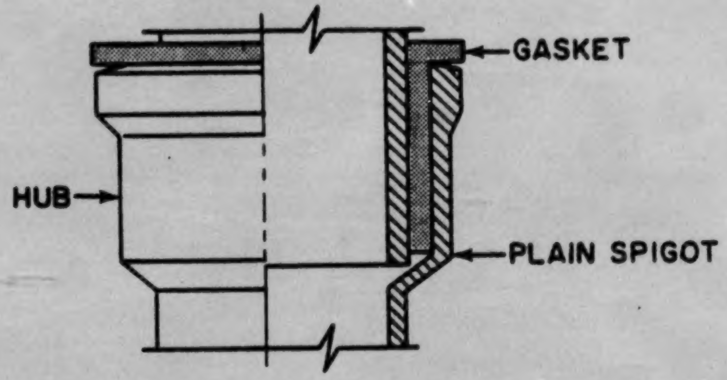
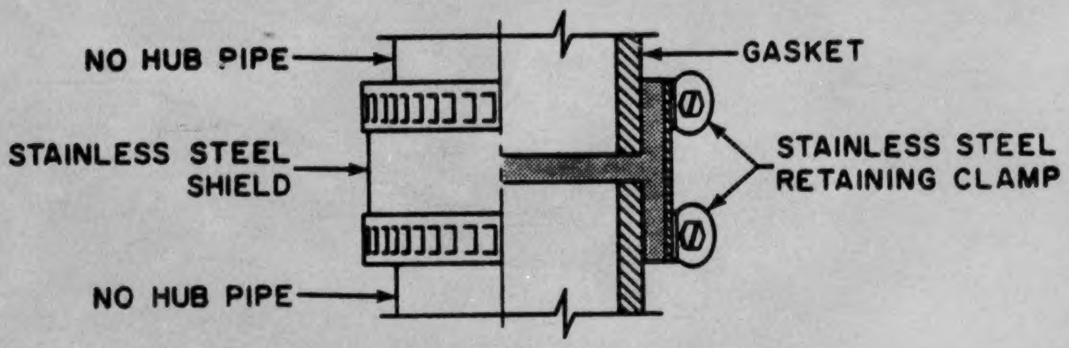
Figure 4-19. No-hub and neoprene joints.


3/4 TO I INCH LEAD
HUB
OAKUM
PLAIN OR BEADED SPIGOT

A. LEAD AND OAKUM JOINT


GASKET
HUB
PLAIN SPIGOT

B. COMPRESSION JOINT


NO HUB PIPE
GASKET
STAINLESS STEEL SHIELD
STAINLESS STEEL RETAINING CLAMP
NO HUB PIPE

C. NO HUB JOINT

CKC – 123

Figure 4-20. Joints used to connect cast-iron soil pipe and fittings.

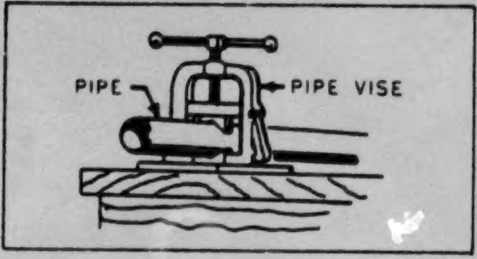


Figure 4-21. Pipe clamped in a pipe vise.

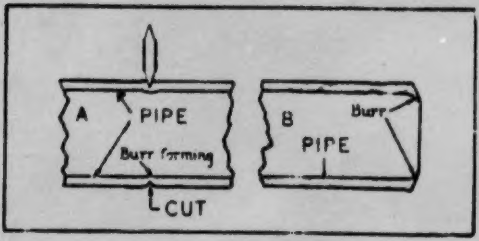


Figure 4-23. The results of cutting pipe with a pipe cutter.

**241. Provide brief answers to questions pertinent to manually cutting and reaming steel pipe.**

**Cutting and Reaming Steel Pipe Manually.** Now that you have learned how to cut and join cast-iron soil pipe, let's learn how to cut and ream steel pipe by hand.

*Cutting steel pipe manually.* After you have measured and marked the steel pipe in accordance with the instructions given in Volume 1, place it in a pipe vise, where it can be held for the cutting operation. A pipe inserted in a pipe vise, ready to be cut with a pipe cutter or hacksaw, is illustrated in figure 4-21. A pipe cutter ready to make the first turn on the pipe to be cut is illustrated in figure 4-22. To cut a steel pipe with a pipe cutter, open the jaws of the cutter by turning the handle counterclockwise. Now, place the pipe cutter around the pipe on the mark where the pipe is to be cut. Center the cutter so that the cutting wheel is on the mark. Close the jaws of the pipe cutter lightly against the pipe by turning the handle clockwise. After the wheels contact the pipe, rotate the handle one-fourth of a turn more in a clockwise direction. This puts a "bite" on the pipe and causes a groove in the pipe when the pipe cutter is rotated. Rotate the pipe cutter one turn to make a complete cutting mark around the pipe before turning the handle clockwise to cut the pipe deeper. If this is not done, the pipe cutter will make spiral marks around the pipe instead of marking one complete circle.

After you make one complete turn on the pipe, turn the handle on the pipe cutter one-fourth turn to take another "bite" on the pipe. Repeat these steps until the pipe is cut. Figure 4-23 shows a cutaway of a piece of pipe and the result when it is cut with a pipe cutter. Part A shows how the cutter causes a burr to form within the pipe, and part B shows a cross section of the burr after the pipe has been cut. This burr must be removed before the pipe is installed, because it will hinder the flow of liquids and gases in a pipe.

*Reaming pipe manually.* The burr is removed from the end of the pipe with a pipe reamer. To perform this operation, insert the point of the pipe reamer into the pipe while it is still clamped in the vise, as shown in figure 4-24, and rotate the handle of the reamer in a clockwise direction in short, even strokes until the burr on the inside of the pipe is removed. A cutaway of a piece of pipe that is reamed properly is illustrated in figure 4-25. It is general practice for a plumber to

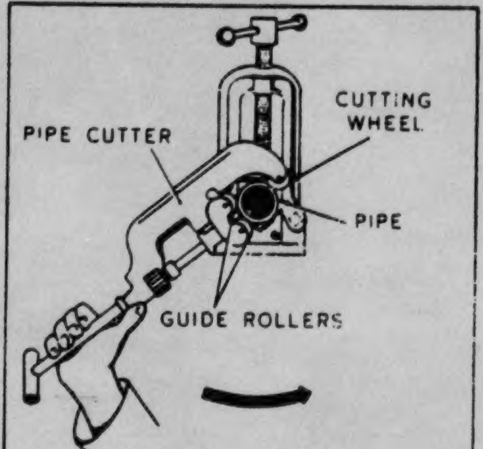


Figure 4-22. Cutting a pipe with a pipe cutter.

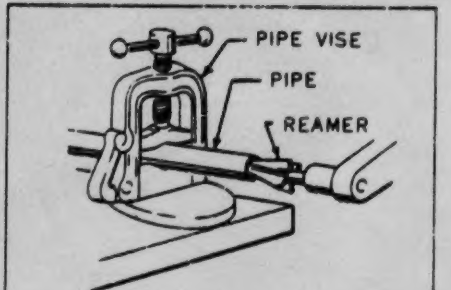


Figure 4-24. Reaming a pipe.

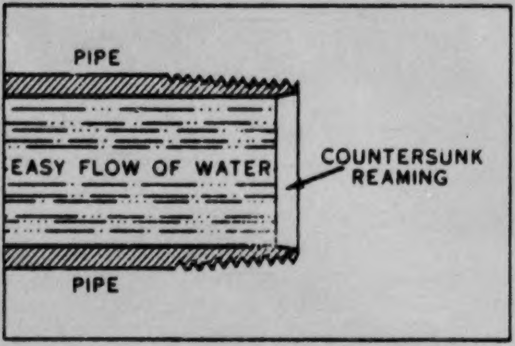


Figure 4-25. Pipe properly reamed.

remove all burrs from pipe, whether it is used for supply, venting, or waste, and from any line that will carry a gas or liquid.

**Exercises (241):**

1. How much should the pipe cutter handle be adjusted on each complete turn?

2. Why must the burr be removed after the pipe is cut?

3. What direction should the reamer handle be rotated?

**242. Match the appropriate response to the statements associated with threading steel pipe by hand.**

**Threading Steel Pipe Manually.** After a piece of pipe has been properly cut and reamed, it can be threaded either by hand or with power tools. Right now, let's find out how steel pipe is threaded by hand.

A ratchet, nonadjustable pipe die stock and pipe-threading dies to fit the stock may be used to cut threads on a piece of pipe. There are other dies, such as a three-way die, that will cut threads on pipe from 1/2 to 1 inch in diameter; and there are larger adjustable dies that will cut threads on pipe from 1 to 2 inches in diameter. You can use the nonadjustable ratchet dies, as shown in figure 4-26, to cut threads on pipe from 1/8 to 2 inches in diameter by changing to the correct size die.

Before you thread a pipe, inspect the dies to see that they are sharp and free from nicks and excessive wear. Then insert the pipe into the vise, place the round guide end of the pipe die stock on the pipe as shown in figure 4-27, and push the pipe-threading dies against the pipe with the heel of the hand. Exert considerable pressure with the heel of the hand against the pipe die stock and make three or four short turns in a clockwise direction to start the pipe-threading dies.

When the dies are started, turn the handle of the pipe die stock, as shown in figure 4-28, with an even and steady pressure until approximately two newly cut threads project beyond the head of the die.

NOTE: To cut clean threads for watertight and airtight joints, you must oil the pipe-threading dies after every two or three downward strokes with a good grade of lard or sulphur pipe-thread-cutting oil. The oil prevents the pipe-threading dies and the threads from overheating and the threads from becoming marred.

When the proper number of threads is cut on the pipe, reverse the ratchet on the pipe die stock for counterclockwise operation and make several short motions backward and forward with the pipe die stock to loosen the burrs that are still inside the pipe-threading dies. Turn the pipe die stock counterclockwise until the pipe-threading dies are free of the threads.

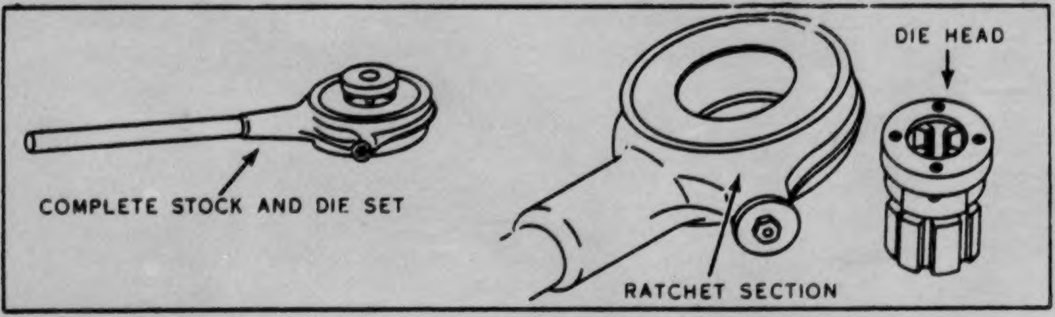


Figure 4-26. Nonadjustable stock and die set.

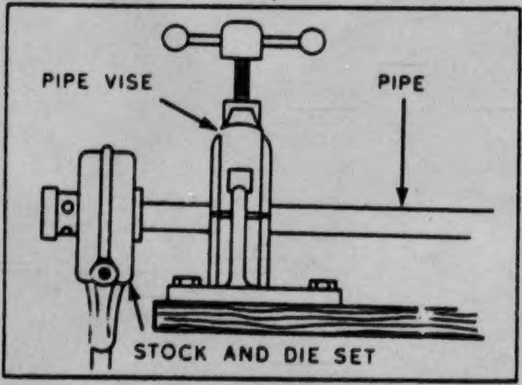


Figure 4-27. Placing die stock on pipe.

Too many pipe threads are just as bad as too few. A normal set of tapered pipe threads on a pipe is illustrated in figure 4-29. Notice how the threads are tapered by the pipe die during the cutting procedure. In section A, the threads are all perfect: in section B, there are 2 threads that are perfect at the root and imperfect at the top. In section C, there are 3 or 4 threads imperfect at both the bottom and the top. This taper on the pipe makes it possible to make a tight and leakproof joint when a pipe is screwed into a fitting. Since you will be cutting threads on pipes with adjustable dies, you must know how to cut the correct number of threads when you use this tool. To cut the proper number of threads on a pipe with an adjustable die, run the die on the pipe far enough so that about two full threads extend beyond the head of the die.

The amount of threads cut per inch is determined by the size of pipe that is to be threaded. Pipe sizes from 1/4 to 3/8 inch have 18 threads per inch; 1/2- and 3/4-inch pipe sizes have 14 threads per inch; 1- to 2-inch pipe sizes have 11½ threads per inch; and pipe sizes 2½ inches through 6 inches have 8 threads per inch.

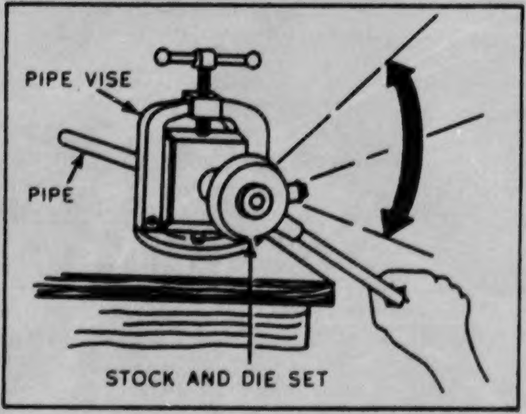


Figure 4-28. Threading pipe with a ratchet and die.

**Exercises (242):**

Match the responses in Column A to the statements in Column B.

| *Column A* | | *Column B* |
|---|---|---|
| a. 11½ | ___ 1. | Approximate number of threads that should project beyond the head of the die. |
| b. 2 | ___ 2. | Number of threads that should be cut on 1- to 2-inch pipe. |
| c. 1/8 to 2 | ___ 3. | Sizes of pipe in inches that nonadjustable dies will thread. |

## 4-3. Cutting, Reaming, and Threading Pipe with Power Tools

Using power tools to cut, ream, and thread pipe is a great timesaver, but it can become a very dangerous operation if not properly done. There are many different types of pipe-threading machines, but each one accomplishes the same purpose when properly used. Among some of the more common types of threading machines are the power-driven bench threader, the power-driven vise stand, and the gear type pipe threader.

### 243. Answer questions relating to the correct operation of power bench threaders.

**Power-Driven Bench Threader.** A bench type threading machine, like the one shown in figure 4-30, is usually found in every plumbing shop. The bench threader is designed to cut and ream the pipe as well as thread it.

To cut the pipe with this machine, insert the pipe

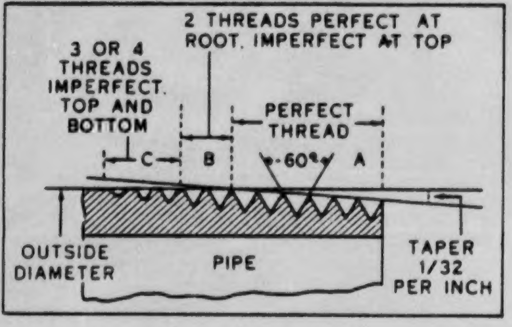

3 OR 4 THREADS IMPERFECT, TOP AND BOTTOM
2 THREADS PERFECT AT ROOT, IMPERFECT AT TOP
PERFECT THREAD
C
B
60°
A
OUTSIDE DIAMETER
PIPE
TAPER 1/32 PER INCH

Figure 4-29. Standard tapered pipe thread.

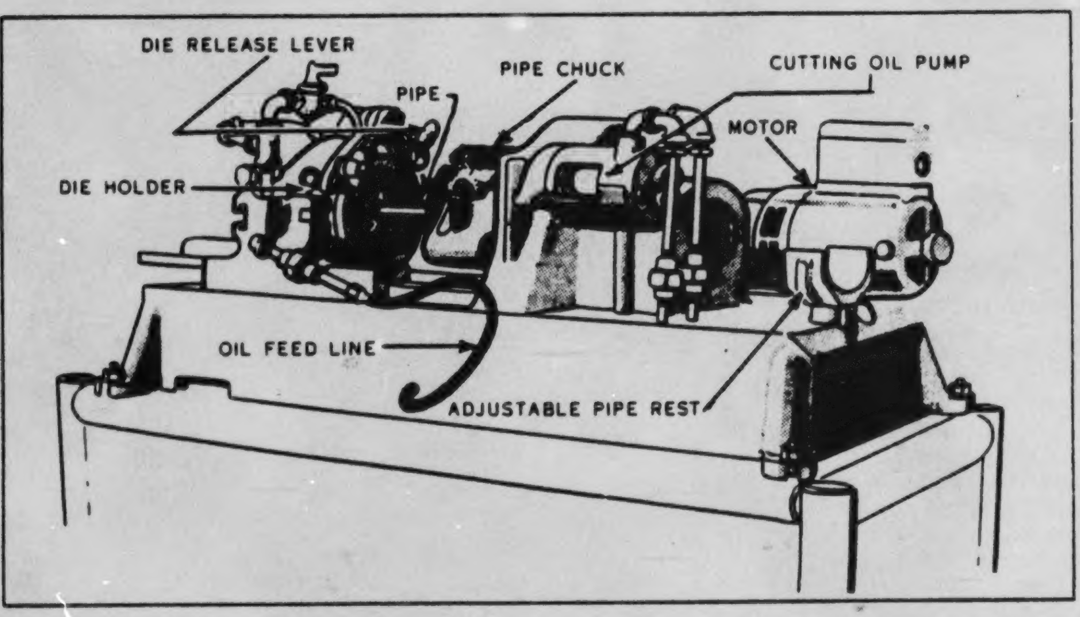


Figure 4-30. Power-driven bench pipe-threading machine.

into the chuck so that it protrudes about 8 inches beyond the face of the chuck. Adjust the pipe rest to carry the weight of the pipe that extends beyond the end of the machine. Now tighten the chuck onto the pipe and start the machine. Advance the pipe dies and pipe cutter until the wheel of the cutter, located behind the pipe chuck, is directly in line with the mark on the pipe. Do not strike the face of the chuck with the pipe dies as you move them to the mark to be cut. When the cutter is lined up with the mark, apply pressure to the cutter as the pipe rotates until the pipe is completely cut off. If the pipe section is long, make sure that there is a pipe rest properly positioned to prevent it from dropping to the floor and possibly damaging the threads. After the pipe section is cut off, withdraw the pipe dies and cutter from the pipe.

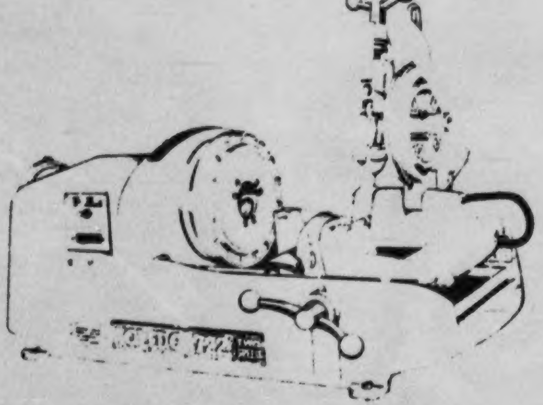


Figure 4-31. Portable power-driven bench threader.

The next operation after cutting the pipe is to ream it to remove the burr caused by the cutter. To do this, insert the pipe into the chuck and let it extend toward the dies the proper distance. Lift the reamer into place. It should fit directly in front of the dies. Move it toward the protruding pipe until it enters and touches it. Next, apply pressure to the reamer until the pipe is properly reamed. Withdraw the reamer from the pipe. Finish the job by removing the reamer from the front of the dies.

Before a piece of pipe is threaded on a power-driven threading machine, check the pipe chuck jaw teeth to see that they are clean and free of pipe chips or flakes. If they need to be cleaned, use a stiff wire brush to remove the dirt and chips so that the teeth will clamp against the pipe without slipping. After the teeth of the chuck have been cleaned and opened to receive a piece of pipe, insert the proper size die into the slots and insert the die-holder pins. Then check to see that all the teeth on the pipe segments are clean and not chipped. When this is done, move the die-releasing handle up and down to see that the segments in the dies will open all the way and will come down the proper distance. Take a short nipple and screw it into the die segments by hand to see that the segments are properly alined. If you prefer, you can check the alinement of

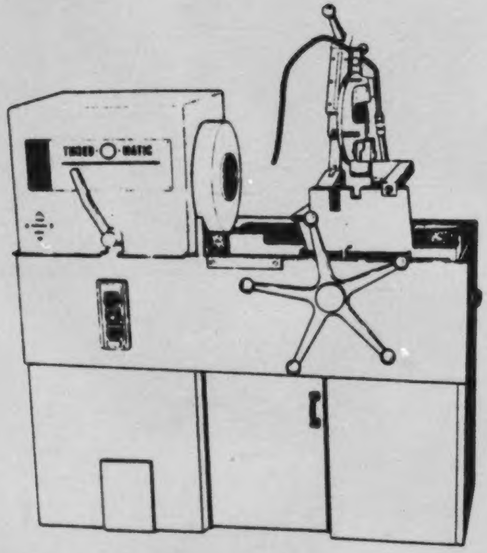


Figure 4-32. Stationary bench threader.

the segments by putting the nipple into the chuck, starting the machine, and running the dies onto the nipple. When the segments are run the proper distance, release them by lifting the die-release lever. Back off the die and shut off the motor, stopping the chuck. After the chuck stops, release the chuck and remove the nipple; check it with a standard female tapped fitting. You should be able to screw the nipple into the fitting by hand about 3 to $3^{1}/_{4}$ turns. If the nipple screws more than $3^{1}/_{2}$ turns, the segments are set too deep. However, if the nipple will screw only about 2 turns, the segments are worn out or are improperly set (too shallow). Figure 4-31 illustrates a portable power-driven bench threader.

After the chuck and dies have been properly cleaned and set, you are ready to start threading the pipe. Make sure that the release lever is in the closed position and move the dies up to the end of the pipe. Before you apply pressure on the dies, be sure you have the oil running to help start the segments on the pipe. Apply enough pressure until at least two threads are started so that the die will continue to thread itself. Allow the machine to operate until the end of the pipe comes through the die head about two full threads, and then release the segments by lifting up on the release lever. Back off the die stock until it is clear of the pipe. Then stop the machine and loosen the pipe in the chuck so that you can remove the threaded pipe from the machine.

Figure 4-32 illustrates a stationary bench threader that may be used to thread pipe sizes 1/2 to 4 inches.

CAUTION: Never attempt to open the chuck while the threader is in motion.

**Exercises (243):**

1. What operation should take place after the pipe is cut?

2. What tool should be used to clean the chuck of a pipe threader?

3. How far should you be able to screw a properly threaded pipe into a fitting by hand?

**244. Choose the true statements concerning the operation of portable vise stands.**

**Portable Vise Stand.** Another type of thread-cutting machine that you will probably use is the portable power-driven vise stand, shown in figure 4-33. This machine is so designed that it turns the pipe to be cut or threaded while the threader is resting on the arms of the machine. The pipe to be cut, reamed, and threaded is inserted in the chuck in the same manner as in the power threading machine mentioned previously. The portable vise stand is equipped with a chuck which grips pipe from 1/4 to 2 inches in diameter. It is powered by a reversible, variable-speed electric motor. Other equipment used with the vise stand is the pipe cutter, the reamer, and the threader. A pipe vise is bolted to the top of the machine.

To operate the portable vise stand, insert the pipe into the chuck and tighten it. Turn on the electric motor to see that the pipe rotates in the proper direction for reaming and cutting threads. When cutting pipe, place the cutter on the pipe and allow the handle of the reamer to rest against either one or both

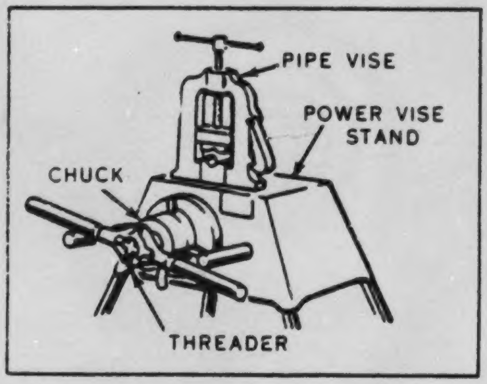


Figure 4-33. Power-driven vise stand.

of the bars as required. Start the machine and control the cutting action of the cutter through the handle. The pipe is reamed in a manner similar to that in cutting the pipe. To cut threads with a vise stand, you should start two or three threads on the pipe by hand with a ratchet handle. This method should be followed in every case when you use power thread-cutting equipment. Start the machine and cut the required number of threads. After the threads are cut, stop the machine, push the bars back, and turn the threaders off by hand rather than run the machine in a reverse direction.

CAUTION: When you use this machine, be sure to rest the handles of the cutter, reamer, and threaders against the bars. Many plumbers have injured themselves by attempting to hold the handles of these units by hand. Remember, if you let go of the handles, they are likely to strike you or catch in your clothes and pull you off your feet before the machine can be stopped.

**Exercises (244):**

Choose the true statements by placing a T in the appropriate spaces.

____ 1. The portable vise stand is equipped to check pipe sizes from 1/4 to 2 inches.

____ 2. The power vise is designed so that the dies turn while the pipe stays stationary.

____ 3. When cutting threads with the power vise, you should part two or three threads by hand.

### 245. Distinguish between the correct and incorrect statements pertaining to the operation of geared type threaders.

**Geared Type Threader.** The combination geared type threader and power vise stand, shown in figure 4-34, is used to cut threads on pipe larger than 2 inches in diameter either in the field or shop. The geared type threader is turned by power from the vise stand through a flexible shaft or a shaft with two universal joints. To thread pipe after the equipment is set up, as shown in figure 4-34, clamp the pipe to be threaded in the vise and let it extend far enough beyond the vise to fit into the threader. After the proper sized segments are installed in the threader, it can be placed over the end of the pipe so that the segments strike or touch the pipe and are in proper alinement. Next tighten the setscrews on the reverse side of the pipe threader against the pipe so that the sleeve will remain stationary while the segments and the outer section of the pipe threader turn. In order to cut the proper amount of standard threads, the outer section has to be turned counterclockwise until the markings on the head are in alinement before it is placed on the pipe. When the threader is installed on the pipe, cut two or three threads by hand, and then apply power to finish the job.

Be careful when you are installing this type of geared pipe threader on a section of pipe to be cut, because it is heavy. Normally, two plumbers work together during this operation. The Air Force does not expect you to completely set up and cut threads on large pipe by yourself until you become proficient in the use of power tools.

Cutting, reaming, and threading pipes with power machinery are common operations, but they can be dangerous too. Most plumbers have cut, reamed, and threaded pipe with power machines so many times that it has become a routine job with them. Usually, during routine work safety precautions become relaxed, causing plumbers to get hurt. They may cut their hands, drop pipe on their feet, get their clothes caught in a turning part of a machine, or get hit by revolving handles. Remember, when you work with power machinery, keep your mind on your work and don't get in too much of a hurry.

One kind of threading involves cutting threads into the side instead of the end of a pipe. It may be necessary for you to drill and tap steel, wrought-iron,

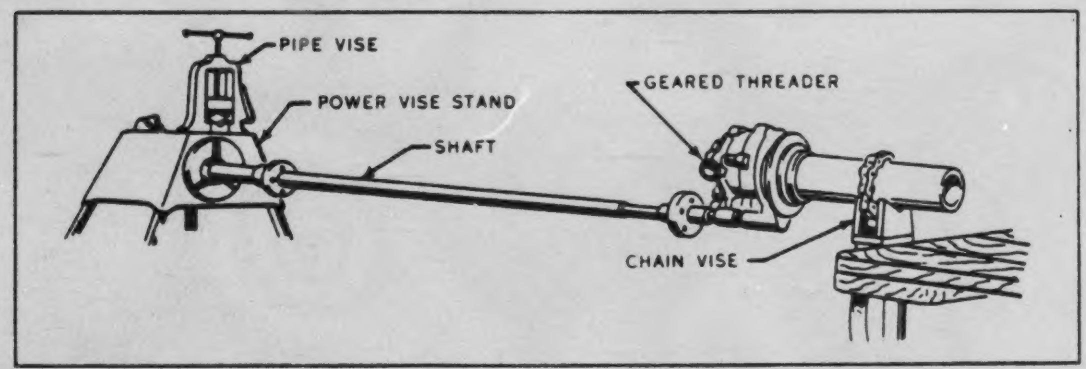


Figure 4-34. Cutting threads with a geared type threader and power vise stand.

cast-iron, or asbestos-cement pipe. The first step is to locate the exact center of the hole to be drilled. Center punch this location so that the drill will not wander. Drill the hole, being careful to hold the drill at 90° to the surface. Be careful not to exert too much pressure when the drill breaks through on the opposite side; by so doing you will leave a smooth surface and avoid breaking out pieces of the pipe. Start the tap into the hole. Hold the tap at 90° to the surface. Use the proper lubricant and turn the tap slowly into the hole. Turn the tap back to clean the threads and to prevent binding and breaking the tap. When the tap has been turned through the pipe, turn it backward and remove it from the hole. Clean the tap and place it in the box or other container, which will protect it from damage.

**Exercises (245):**

Distinguish between the correct and incorrect statements by placing a C for those that are correct in the spaces provided.

_____1. A geared type threader and power vise stand is used to thread pipe larger than 2 inches.
_____2. Normally, two plumbers are required to operate the geared threader.
_____3. The geared threader is self-starting.
_____4. Cutting your hands and getting loose clothing caught on turning parts are hazards related to threading pipe.

## 4-4. Cutting, Reaming, and Threading Copper, Brass, Plastic, and Chromium Pipe

Now that you know how to cut and thread cast-iron soil pipe and steel pipe, let's complete this pipe-cutting and pipe-threading discussion by learning how to cut and thread copper, brass, plastic, and chromium-plated pipe.

**246. Tell (1) what should be used in vises and chucks to prevent marring copper or brass pipe, and (2) how light copper and brass pipes are usually threaded.**

**Cutting and Threading Copper and Brass Pipe.** Copper or brass pipe may be cut and threaded with either handtools or power tools. In either case, you must be careful to prevent marring the pipe with teeth marks when it is placed in holding tools, such as vises and chucks. Two types of clamps that can hold pipe without marring it are shown in figure 4-35. These clamps may be used with power-driven machines as well as with stationary pipe vises. When brass or copper pipe is to be cut, reamed, or threaded on a power machine, insert two suitable lead-lined sleeves between the chuck jaws and the pipe. Tighten the chuck enough to prevent the pipe from slipping and turning while you are performing the various operations.

Large copper or brass pipe can be reamed with a hand reamer, or if it is cut with a power-driven machine, it can be reamed in the same manner as steel pipe.

On light pipe, a clamp can be made with either hard wood or iron blocks, lined with a lead sleeve, and inserted into a pipe vise to help hold the pipe. Light pipe is very seldom threaded on a power machine. If it is to be threaded, it is usually done by hand.

**Exercises (246):**

1. What should be inserted in vises and chucks to prevent marring copper or brass pipe?

2. How is light copper and brass pipe usually threaded?

**247. Select the true statements pertaining to cutting, reaming, and threading plastic and chromium-plated pipes.**

**Cutting and Threading Plastic and Chromium-Plated Pipe.** You must also be careful when you are

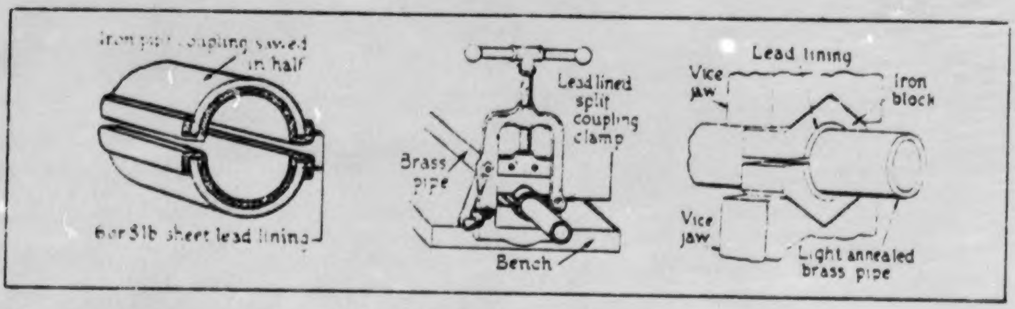

Iron pipe coupling sawed in half
6 or 8 lb sheet lead lining
Lead lined split coupling clamp
Brass pipe
Bench
Lead lining
Vice jaw
Iron block
Vice jaw
Light annealed brass pipe

Figure 4-35. Clamps used to hold brass, copper, plastic, or chromium pipe in a vise or chuck.

cutting and threading chromium-plated pipe to keep from scratching or marring the pipe. Follow the same precautionary measures that should be observed when you cut brass or copper pipe. Chromium pipe is cut with a tube cutter or a hacksaw. When you cut this pipe, make sure that your tube cutter is in good working order and that it does not have a rough wheel; otherwise the chromium finish will be marred or possibly scratched. When threading chromium pipe, first check to see whether a standard thread or a butt joint thread is required. In most cases, a butt thread will be necessary. It is common practice for the plumber to cut and thread this type of pipe by hand because of the special care that must be taken during the threading operation. Before you start to cut a thread on chromium pipe, check the dies on a piece of pipe that is not chromium plated to make sure that they are properly set to make a butt-threaded joint.

With the dies set and checked, be sure to make the proper number of threads. Often, plumbers fail to cut the proper number of threads to make a butt joint. Then, when the pipe is installed, it does not make up properly and usually leaks. Setting the dies too deep or not cutting enough threads usually causes leaks.

The same precautions should be taken when cutting, reaming, and threading plastic pipe as when working with copper, brass, and chromium-plated pipe. To be threaded, plastic pipe should be at least schedule 80 or heavier. Even though plastic pipe can be threaded, it is recommend that precast threaded fittings be used when making threaded connections.

A large tubing cutter works well when cutting plastic pipe. However, a carpenter's handsaw with a miter box will give you an acceptable cut.

**Exercises (247):**

Select the true statements by placing a check mark (√) in the appropriate spaces.

____ 1. In most cases chromium-plated pipe will require a butt thread.

____ 2. The sole cause of leaks on butt-threaded joints is not having enough threads cut.

____ 3. Plastic pipe of schedule 80 or heavier may be threaded.

____ 4. A carpenter's handsaw and miter box can be used to cut plastic pipe.

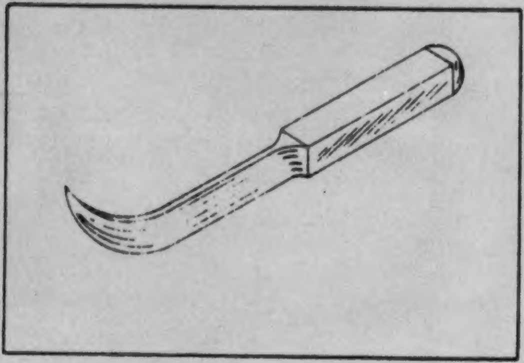


Figure 5-5. Pickout iron.

into the pipe, pour in 5 gallons of boiling water. Then close the tops of the pipes to prevent the odor of peppermint from escaping. As when making a smoke test, the inspector should remain away from the area until the test is prepared. He must be able to locate leaks in the system by detecting the odor of the peppermint.

When is it best to use each kind of test? Use the smoke test when testing waste systems which have been in prior operation. Use the peppermint test for the final testing of a new waste system after the fixtures and traps have been installed. Use the water test for rough-in inspections, and use the air test for rough-in tests during freezing temperatures.

**Exercises (248):**

Match the responses in column A to the statements in column B by placing the appropriate letter in the spaces provided.

| *Column A* | | *Column B* |
|---|---|---|
| a. Air test | ___ 1. | Fill the system and let stand 12 to 24 hours |
| b. Water test | ___ 2. | Use oily waste as part of the test. |
| c. Smoke test. | ___ 3. | Uses 5 gallons of boiling water. |
| d. Peppermint test | ___ 4. | Test with 5 psi for 15 minutes. |

## 5-2. Repairing Waste Systems

As a plumber, you must know not only how to test a waste system but also how to repair it if you discover a leak when making the test. First, let's discuss repairing leaks in cast-iron soil pipe.

**249. State actions to be taken pertaining to repairing leaks in cast-iron soil pipe.**

**Repairing Leaks in Cast-Iron Soil Pipe.** When a water test is made, any lowering of the water level greater than 4 inches in 30 minutes indicates a leak in the system. Leaks occur most commonly at lead-calk joints, and they can be detected by moisture seeping through the joint. When a leak is detected, recalk the lead with an inside calking iron and then with an outside calking iron as when making the original joint. Most leaks can be repaired by this recalking process. If the leak continues, you must remove the lead and oakum and recalk the joint. The lead and oakum can be removed with a pickout iron, as shown in figure 5-5. Drain the water to a level below the leaking joint before you make the repair. Do not apply heat to melt the lead in the joint, because steam from the moisture in the oakum may cause the hot lead to blow out and injure you or your coworkers. After removing the lead and oakum from the leaking joint, you can apply heat to the bell to dry out the moisture in the pipes before you recalk the joint with oakum and molten lead.

When you make an air test, a drop in the mercury column on the gage indicates a leak. Apply soapy water with a brush on the area where you think the leak is located. If there is leakage in the area, it will be indicated by the forming of bubbles. For cast-iron fittings this test is very effective in locating leaks that are caused by sand holes made during casting or by cracks from rough handling. When you locate such leaks, you must replace the fitting. Never attempt to repair a fitting by welding, brazing, or any other such means. Remove the faulty fitting and the pipe which connects to the hub end of the fitting. Replace the faulty fitting with a serviceable one, and calk and lead the spigot end of the fitting into place. A special insertable type joint with a deep hub, known as the session joint, shown in figure 5-6, is available for replacing the pipe section in the hub end of the new

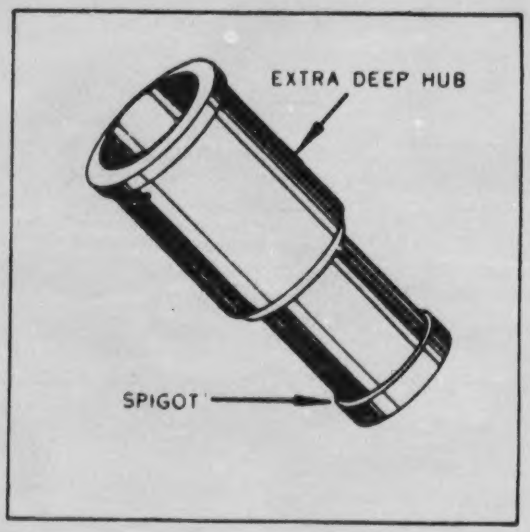


Figure 5-6. Insertable (session) joint.

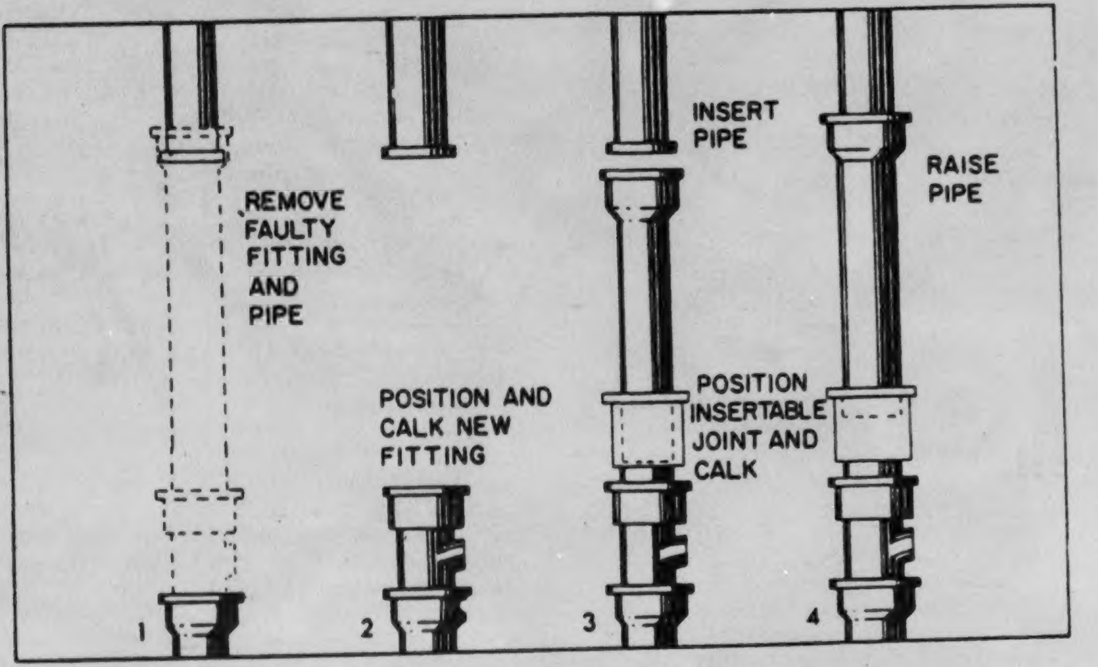

REMOVE FAULTY FITTING AND PIPE
POSITION AND CALK NEW FITTING
INSERT PIPE
POSITION INSERTABLE JOINT AND CALK
RAISE PIPE
1
2
3
4

Figure 5-7. Replacing pipe by using an insertable joint.

fitting. The spigot end of the insertable joint is calked and leaded into the bell end of the new fitting. Since the hub of the insertable joint is extra deep, the design allows the last section of pipe to be lowered into the deep hub and then raised into place for calking. This procedure is illustrated in steps 1, 2, 3, and 4 of figure 5-7.

**Exercises (249):**

1. What should you do when a leak is detected in a calked joint?

2. What tool is used to remove lead from a moist calk joint?

3. What type of special fitting is used when a single length of soil pipe needs to be replaced?

**250. Name fitting to be used or state precaution to be observed in given situations concerning leaks in threaded pipe connections.**

**Repairing Leaks in Threaded Pipe.** You must know how to repair leaks in threaded pipe as well as in cast-iron soil pipe. To complete our discussion, then, let's turn our attention to the subject of repairing threaded pipe.

When leaks are detected in threaded pipe joints, it is usually necessary to remove and reinstall the piping. You can rarely correct leaks by tightening the joint, because as the thread on one end is tightened, the thread on the opposite end of the pipe is backed out

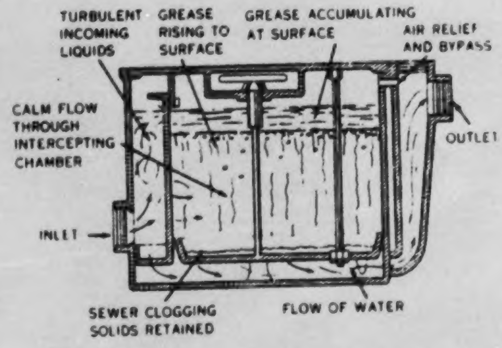

TURBULENT INCOMING LIQUIDS
GREASE RISING TO SURFACE
GREASE ACCUMULATING AT SURFACE
AIR RELIEF AND BYPASS
CALM FLOW THROUGH INTERCEPTING CHAMBER
OUTLET
INLET
SEWER CLOGGING SOLIDS RETAINED
FLOW OF WATER

Figure 5-8. Typical grease trap.

and will probably leak. Never attempt to close a leak in threaded joint with compound. To stop the leak, you must get the compound between the threads of the pipe and fitting and tighten the joint. Sections of the piping may be cut out with a pipe cutter so that the joints can be properly tightened. The piping is then replaced, and the final joint is made with a Tucker connection. Never use pipe unions when repairing leaks in the waste or vent piping.

Be sure you support and brace the piping, especially vertical pipe runs, before you remove a section from the system for repair. This precaution prevents the remaining pipes from moving or shifting, which could cause strain or damage to other joints.

**Exercises (250):**

1. What type fitting should be used to make the final connection when repairing a leak in a threaded waste system?

2. What type screw fitting should never be used when repairing leaks in a waste or vent system?

3. What precautions should you take before removing a section of a vertical run of pipe for repairs?

## 5-3. Grease Traps

Without grease traps there would be many more sewer stoppages. Grease traps are a must in all kitchens other than residential. Properly installed and maintained grease traps will aid immeasurably in the operation of sewers.

**251. Provided a list of statements associated with the installation and maintenance of grease traps, choose the correct statements.**

**Installation and Maintenance of Grease Traps.** Removing grease from greasy wastes is essential to the proper functioning of a sewer system in large military or commercial kitchens. In such kitchens, if large quantities of grease are allowed to pass into the waste system, it will solidify and clog the waste pipes. To prevent this condition, some means must be used to collect the grease before it enters the waste system. Grease traps are used for this purpose.

*Construction and operation of grease traps.* Grease traps may be constructed of concrete, brick, or metal in various sizes. A number of different types of grease traps are available, but they all work in accordance with the principle that grease is lighter than water and therefore will rise to the top of water. In the common air-cooled grease trap, like the one shown in figure 5-8, the incoming water passes through a series of baffle chambers where the grease is cooled and rises to the top of the water. Water, free from grease, is drawn from the bottom of the trap and passed in to the sanitary sewer system. As you can see in figure 5-8, the unit is only as efficient as the service it receives. In a very short period of time, the grease trap fills and ceases to remove grease. When this happens, the unit must be cleaned.

*Installation of grease traps.* A grease trap should be installed as close to its fixture as possible, preferably in a location where the odor will not get into the kitchen when it is opened to be cleaned. The ideal place is outside the building. Since grease traps must be cleaned periodically, they must have a removable cover. Some grease traps are connected to a hot and cold water supply for flushing after the accumulated grease has been removed.

*Maintenance of grease traps.* Periodic cleaning is all that is necessary for the proper maintenance of a grease trap. To clean a small grease trap, remove the cover and dip the grease out of the trap with a ladle. In cases of sewer and waste stoppages at large military or commercial kitchens, the first step is to see that the grease traps are clear.

Plumbing personnel usually clean the grease traps that are located outside the building. They usually use an ordinary perforated scoop to skim the grease from the surface of the trap and place it in suitable containers for salvage. The next procedure is to remove as much of the putrid material as possible with the same scoop and treat it as refuse material to be destroyed. Pump out the liquid contents from the traps every 3 months and scrape all the sediment from the sidewalls and bottom. Finish the operation by flushing the trap with clear water.

**Exercises (251):**

Choose the correct statements by placing a C in the appropriate spaces.

____ 1. Grease traps work on the principle that grease is lighter than water.

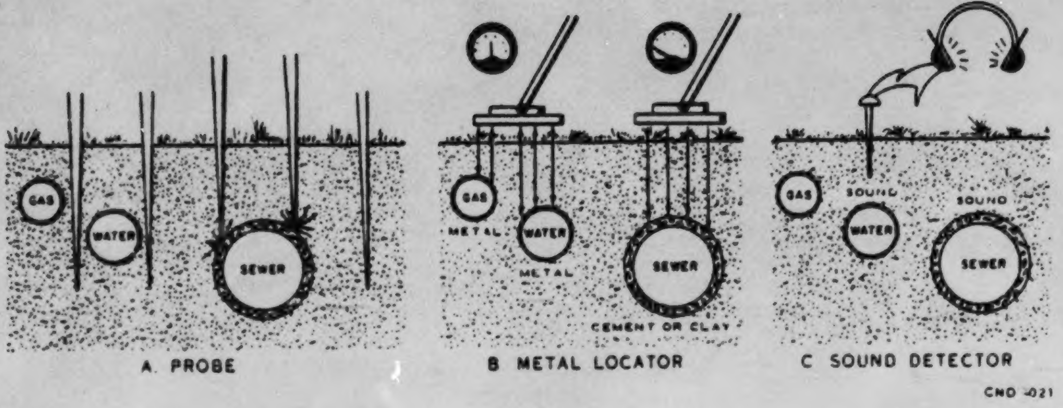
____ 2. Water free from grease is drawn from the top of the trap.

____ 3. The ideal place for a grease trap is outside the building.

____ 4. The liquid contents of a grease trap should be pumped out every three months.

## 5-4. Inspection and Maintenance of Sanitary Sewers

Inspection and maintenance of sewer systems is scheduled on a recurring basis. Checking the manholes will allow you to determine if there is a partial flow of sewage. A well maintained sewer system will eliminate



A. PROBE B METAL LOCATOR C SOUND DETECTOR

Figure 5-9. Locating buried pipes.

most of the overtime work resulting from main sewer stoppages. By this point in your career as a plumbing specialist, you most likely have been introduced to after-duty-hours sewage stoppages, some of which could have been prevented if a good maintenance program had been followed.

**252. From a given list of statements relating to inspection of main sewers, distinguish between those that are true and those that are false.**

**Inspection of Main Sewers.** Like water systems, sewer systems must be inspected periodically to insure continued satisfactory service. Small discrepancies, if corrected, will prevent major system failures later. When a failure occurs, however, its cause must be determined and corrected.

*Locating buried pipe.* Main sewer systems must be inspected periodically for condition and operation. Locating the sewer pipe is an operation accomplished for inspection as well as later maintenance and repair.

Visual sighting between manholes for the most part is a reliable method of locating buried sewer mains. Obstruction may prevent visual sighting. Maps must be consulted in such cases to determine pipe location.

This is especially important if repair is required. Other piping systems may cross the sewerline or run parallel nearby. The map generally has a legend which identifies the symbols used for each piping system.

Electrical instruments are sometimes used to locate buried sewer pipe. One instrument may detect pipe magnetism. Such instruments are reliable only when sewer lines are of a metallic composition.

Sound-detecting instruments can be used to locate buried pipe that conveys liquids. Sound-detecting instruments operate on the principle of listening to liquids moving through the pipe. Sound-detecting instruments are reliable only when no other piping conveying liquids is nearby.

Probing for the exact location of buried pipe is probably the most reliable method. Not only its location but depth can be determined, see figure 5-9, locating buried pipes.

*Inspecting main sewers.* Sewer mains are constructed with manholes at intervals of 300 feet. These are used to gain entrance to a sewer main. Manholes are usually located in the center of a street and covered with a round iron lid. All the work done when cleaning a main sewer is done through a manhole. Before entering a manhole, remove the cover and allow the sewer gas to escape. This gas is dangerous if ignited and will burn or explode, causing injury to personnel. Breathing the gas is also dangerous to personnel.

CAUTION: Never enter a sewer manhole without someone standing by to go for help in case the one entering the manhole is overcome with gas. A rope tied around the body and under the arms of the man entering the manhole is recommended so that he may be pulled out if he is overcome by gas.

After it has been determined that the sewer is safe, you may begin inspection and maintenance operations.

*Methods of checking for flow.* You can detect obstructions in the main sewer by observing flow at manholes. You can check for obstructions between manholes by performing the following steps:

- Plug off a section of sewer main at manholes with sandbags or pneumatic ball.
- Fill section of sewer line and manhole with water.
- Remove plug and observe rate of flow at next manhole.

Slow rate of flow at the next manhole indicates an obstruction in the line between the two manholes. Fast rate of flow at the next manhole indicates no obstruction in the line between the two manholes.

Another way of detecting restrictions between manholes is by comparing the level of sewage at one

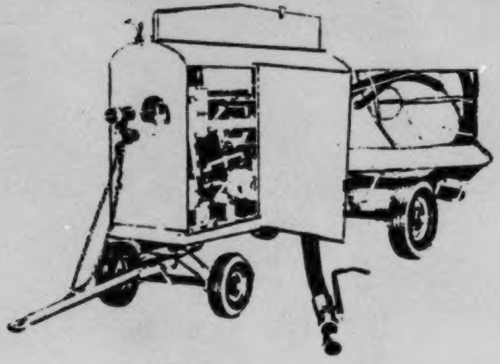


Figure 5-10A. Typical power sewer auger.

manhole with the level of sewage at the next manhole downstream. If the level of sewage at the upstream manhole is greater than the level of sewage at the downstream manhole, then there is restriction in the line between the two manholes, provided the line is the same size.

**Exercises (252):**

Distinguish between the true and false statements by placing a T or F in the spaces provided.

____ 1. Maps should be consulted to locate buried pipes.

____ 2. Probing for pipe is not a reliable method of locating buried pipe.

____ 3. Manholes are placed in sewer mains at 300-foot intervals.

____ 4. Never enter a manhole without someone standing by to help in case of an emergency.

____ 5. Obstruction in sewer mains can be detected by observing the flow in manholes.

### 253. Select and mark the correct statements pertaining to maintenance of main sewers.

**Maintenance of Main Sewer.** There are two types of maintenance for main sewers which will concern you. They are recurring and emergency maintenance. Recurring maintenance is scheduled into the shop on an annual basis. The time of year you perform this type of maintenance will depend upon the geographical location. In areas where the snowfall is several feet annually, it would not be practical to perform recurring maintenance in midwinter, not so much because of the extreme cold weather, but the time it would take to locate and remove the snow from the manhole covers. During recurring maintenance is the time to check for flow levels and clean debris from manholes. Should a partial stoppage be found, it should be removed, either with a sewer auger or a pressure sewer cleaner (see figs. 5-10A and 5-10B). Flushing sewer mains by adding additional water with a fire hose will help keep the sewer in better operational condition.

Emergency maintenance may occur at any hour of any day. For example, sewers may be broken by equipment or earth shifting. Also they may be stopped up. These are some of the problems which will confront you.

Once the trouble has been determined, you should make the necessary repairs. Let's say you have found a restriction or stoppage in the main sewer. This can be dealt with, in short order, with a power sewer auger. Figure 5-10A illustrates a typical power sewer auger used to remove main sewer stoppages.

This machine consists of a J-tube, rod sections, assortment of heads, gasoline engine, and handtools used for changing heads and removing broken rod sections.

The J-tube is used as a guide when inserting the rod into the main sewer.

The rod is extended to the obstruction with the power feed, while the drum rotates clockwise. Once the head has reached the point of obstruction, you should slow the feed and cut through the stoppage at a slow, even speed. The type of head to use will depend upon the type of obstruction. You would use a hook to retrieve rags. You would use a saw-type cutter to cut and retrieve roots.

When retrieving, the drum should be rotating slowly clockwise with the feed lever in reverse; this will keep the obstruction from slipping off the head.

This type of equipment is rather difficult to operate, especially if the stoppage is solid. Therefore, it is a good safety practice to use three men when using the sewer auger.

To repair broken sewer mains, you should block off the pipe to be repaired in the manhole with sandbags or an inflatable sewer bag. Always be sure to have some means of removing the sandbags. Usually a rope

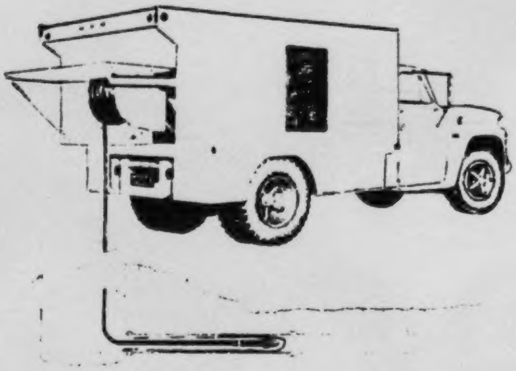


Figure 5-10B. Pressure sewer cleaner.

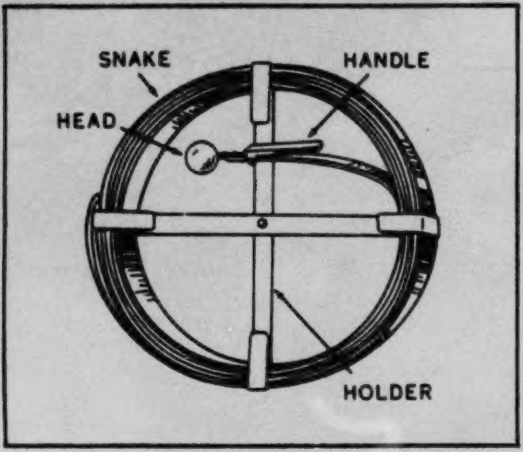


Figure 5-11. Flat sewer snake.

is tied around the sandbag in such a manner as not to slip off the bag when removing it after the repairs have been made. Once you have blocked the flow of sewage, you can make the necessary repairs. Usually the repairs consist of removing and replacing one or more lengths of pipe. Remember, always use good safety practices when excavating and backfilling.

**Exercises (253):**

Mark the correct statements by placing a C in the appropriate spaces.

____ 1. The two types of main sewer maintenance are recurring and emergency.

____ 2. Recurring maintenance is only performed in the summer months.

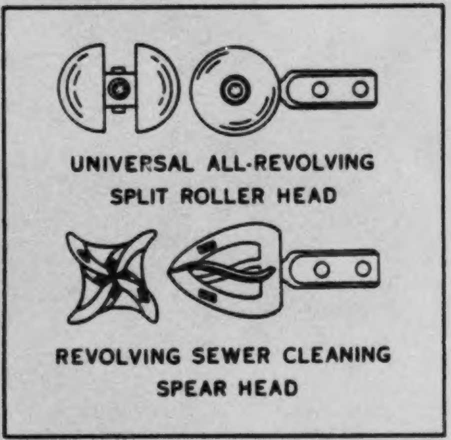


Figure 5-12. Flat sewer snake heads.

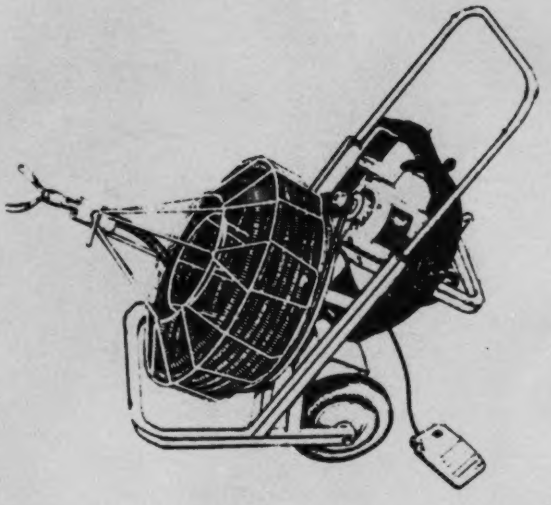


Figure 5-13. Power sewer auger for building sewers.

____ 3. The J-tube is used to guide the rod into the main sewer.

____ 4. The rod drum should be rotating counterclockwise when retrieving an obstruction.

____ 5. Three men should be assigned when using the sewer rods.

____ 6. Sandbags may be used to stop sewage flow for pipe repairs.

### 254. Provide pertinent information pertaining to maintenance of building sewers.

**Maintenance of Building Sewers.** Where sewers are not overtaxed and storm water from sewers does not back up into the buildings, the rise of water and sewage through a floor drain indicates a stoppage either in the house drain or in the house sewer. The cleanout for the building sewer is normally located just outside the building foundation. This is the starting point for using a power-operated sewer auger or a flat steel snake (sometimes referred to as a ribbon snake) to clean the stoppage.

The flat sewer snake, shown in figure 5-11, is one of the simplest tools that may be used to loosen obstructions in a building sewer. Snakes like this one are made of steel ribbon varying in size from 1/4 inch to 1 1/2 inches in width by 1/15 inch to 1/8 inch thick, and in lengths up to 200 feet. The 1/2-inch width is suitable for pipes up to 3 inches in diameter, and the 3/4-inch is suitable for pipes up to 4 inches in diameter.

The flat type sewer snake is designed with a handle with an automatic grip, as shown in figure 5-11, or one locked with a screw. This handle slides along the snake as it is pushed into the drain or sewer. The forward end of the sewer snake is equipped with a split roller head or a spearhead, as shown in figure 5-12.

To dislodge a stoppage in a sewer line with a sewer snake, insert it into the line through the cleanout plug or some other convenient opening. Feed the snake into the sewer, using a back-and-forth movement. When the snake will not feed any further, the head of the snake is probably up against the stoppage. Now, work the snake back and forth until you punch through the stoppage. When the line seems to be draining, run water into the sewer to help clean it.

The electric sewer auger illustrated in figure 5-13 is ideal for cleaning building sewers. This auger is equipped with an assortment of heads: the saw cutter, corkscrew, knife cutter, drop head, and pickup head. This machine also is equipped with a foot control, leaving both hands free to guide the auger. The type of auger head you will use will depend upon the obstruction to be removed.

CAUTION: Always make sure the machine is properly grounded.

**Exercises (254):**

1. What width flat sewer snake should be used to free obstructions in a 4-inch building sewer?

2. At what point in the building sewer would you begin the sewer cleaning operation?

3. What are the two types of heads used on flat sewer snakes?

### 5-5. Inspection and Maintenance of Building Drains

A drainage system that functions properly is of great importance to the general health of personnel. Defective and improperly operating drainage systems may contaminate the potable water supply or food and cause the spread of disease. Therefore, it is of prime importance that you keep the drainage system in good working condition. A contaminated water supply may carry germs which cause typhoid fever, cholera, dysentery, and many other diseases.

**255. Given a list of actions related to the inspection of building drains, select those that are pertinent.**

**Inspection of Building Drains.** Periodic inspection of interior piping systems prevents undesirable conditions and costly repairs.

Loose, broken, or missing pipe supports permit waste pipe to sag, causing undue stress on joints. Leaks in waste systems inside a building are not acceptable. Sagging pipe alters the pipe grade, which in turn changes the drainage flow. Solids will settle in the low area and eventually cause slow drainage or clogging.

Leaks caused by defective joints, pipe, and fittings must of course be corrected for health reasons.

Clogged vents often cause fixture drains to operate slowly. Water may be siphoned from the trap due to vent stoppage. This allows sewer odors and gases to be vented through the fixture drain. Vents may be clogged from debris backed up from a previous line clogging. Birds attempting to nest in the vent terminal may also cause poor venting. The vent pipe itself may have been damaged restricting its venting capability.

The most common problem area you are apt to find when inspecting mess facilities' building drains is missing floor drain covers. With the floor drain covers missing, foreign objects and debris may fall or be swept into the drain, thereby causing stoppages.

**Exercises (255):**

Select the actions that are pertinent when inspecting building drains by placing a checkmark (✓) in the spaces provided.

____ 1. Look for missing pipe hangers and supports.
____ 2. Check for defective joints.
____ 3. Check for oversize vents.
____ 4. Inspect vents for foreign debris.
____ 5. Check floor drain covers.

**256. State required information concerning maintenance of building drains.**

**Maintenance of Building Drains.** The drainage system consists of the piping and fittings needed to carry waste water, sewage, or other drainage from the building to the building sewer or other place of disposal. When trouble arises in the drainage system, the plumber must perform the proper maintenance required to correct the trouble without damaging the system.

**Causes of Stoppages.** When waste pipes from sinks, laundry traps, bathtubs, lavatories, and urinals are correctly sized and sloped, and when standard traps are installed, drainage systems do not become clogged readily with grease, lint, hair, and other materials. Most clogging results from particles of food, lint, and hair which are allowed to collect on and in the strainers. Thus, the rate of discharge of the water is reduced to a sluggish flow, which allows foreign matter to settle in the horizontal pipes rather than being swept on through the system by the stream.

Fats, greases, and oils should never be discarded in a sink unless the system has a grease trap and the trap is properly maintained. Fats, as well as hardened crusts

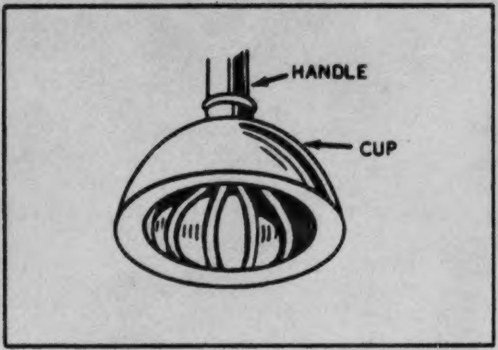


Figure 5-14. Vacuum plunger.

scraped from cooking utensils, and leftover bits of food should be collected in cans that can be thrown away with the garbage.

The most effective method of preventing stoppages from congealed grease that is carried into a drain with dishwater is to run a large amount of scalding water through the pipe for a period of at least 2 or 3 minutes after each dishwashing.

Floor drains are often clogged by floor sweepings and lint from washing clothes. Normally, the strainers are not fine enough to stop the floor sweepings and lint. Be careful not to place sweepings in the trap. The screens should be cleaned often to protect the trap from clogging.

Clogging of urinal drains is a problem because careless individuals drop chewing gum and cigarette butts in the urinal. Enough of this material gets through the screen to cause a stoppage. A smaller screen can be installed that can take care of the chewing gum, but the cigarette butts dissolve and go through the screen and soon cause a stoppage in the trap.

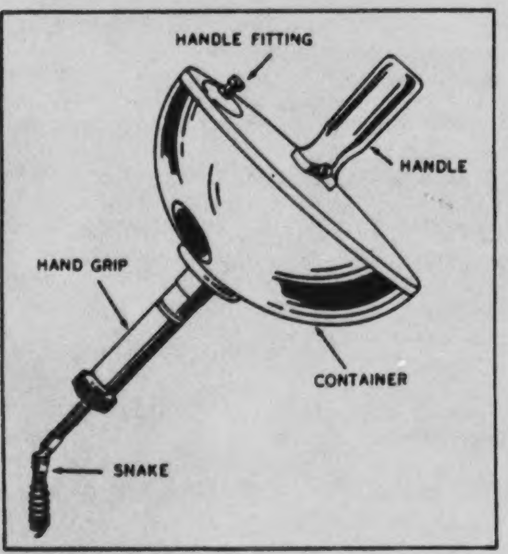


Figure 5-15. Top sink snake.

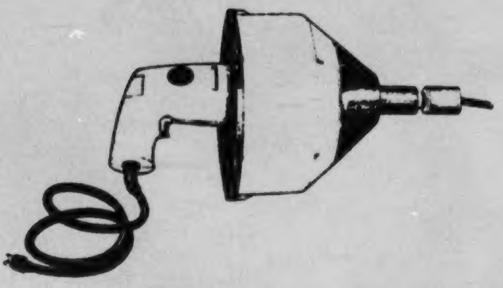


Figure 5-16. Power-driven auger for sink and lavatory drains.

**Opening Clogged Drains.** There are several methods the plumber can use to open clogged drains. These methods include the use of boiling water, vacuum plungers, plumber's snakes, and chemicals. All of these methods take time and require a certain procedure to accomplish the job. A certain amount of precaution is also necessary, especially when chemicals are used, because they can burn the skin.

Usually, when a drain to a fixture clogs, it is best to try first to clear it by using the simplest methods. This will probably include the use of the vacuum plunger and hot water. If these methods fail, chemicals may have to be used if the waste flow is not totally restricted. If the flow is totally restricted, you may have to partially disassemble the system and use the

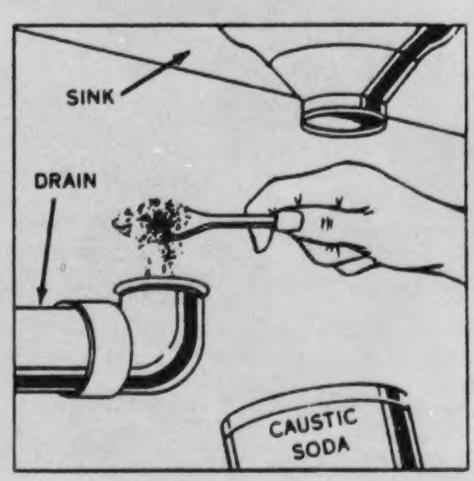


Figure 5-17. Placing a chemical into a waste pipe.

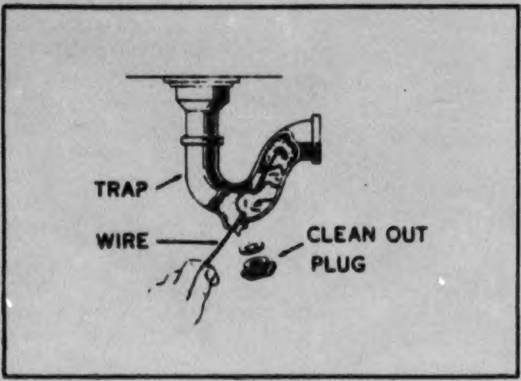


Figure 5-18. Removing stoppage from a P-trap.

appropriate sink or sewer snakes to clear it. After the stoppage is cleared, the waste lines should be cleaned by flushing them with hot water.

*Using a vacuum plunger to clear drains.* When a sink, lavatory, or drain is completely stopped, a mechanical method must be employed to remove the obstruction. The vacuum plunger, shown in figure 5-14, is a simple tool that is often used to clear a sink, lavatory, or drain. This tool is also called a suction cup, force cup, or a plumber's friend. The vacuum plunger consists of a rubber bell-shaped suction cup, about 5 inches in diameter, which is fastened to a wooden handle. To use the vacuum plunger, partially fill the fixture with water and place the force cup over the fixture trap opening. Work the handle up and down several times to create alternate compression and suction pressures through the trap. Continue this action until the stoppage is cleared. When the fixture drains freely again, pour boiling water through the fixture (only cold water through vitreous china fixtures) to flush the trap and waste line.

*Using a sink snake to clear drains.* If you cannot remove the stoppage from the drain with a vacuum plunger, you may have to use a sink or sewer snake to dislodge the stoppage. These snakes are constructed of coiled, tempered wire which is extremely flexible. They are generally 15 to 25 feet long, with a diameter of approximately 1/4 inch. Each snake is equipped with a type of crank that is used to rotate the snake as it is pushed into a clogged drain. As you can see in figure 5-15, a sink snake is housed in a toplike container. This unit is also called a top sewer snake. Figure 5-16 illustrates a power-driven auger used for cleaning lavatory and sink drains. When you use this snake, the top is rotated as the snake is pushed into the drain. In some cases, you may have to remove the trap and elbow from the drain before the sewer snake is pushed into it. Push the snake down the drain and rotate it; then feed it further and rotate it again. Continue this operation until you pierce the obstruction. Usually it is impossible to remove an obstruction from a pipe with a snake; but after you bore a hole through it, you can flush it with hot water or apply the chemical treatment.

In some cases chemicals, force cups, and sink snakes will not open a lavatory, bath, shower, or floor drain clogged with hair; therefore, each system must be disassembled and the hair removed from the screens, traps, or at the base of popup stoppers on lavatories. Sometimes this disassembly can be held down by using a length of wire with one end bent to form a small hook to fish the foreign matter from the drains. If the system has a screen, remove it, and simply pull the hair from the screen.

*Using a chemical to clear drains.* If scalding water does not open a slow drain, you can use a strong chemical cleaner. Most of these cleaners consist of sodium hydroxide (caustic soda). Sodium nitrate and aluminum turnings are also used, in which case ammonia gas is formed to dissolve the grease. The use of lye (caustic soda) alone frequently adds to the grease accumulation more rapidly than it can be removed by water, and then increases the stoppage because it forms a soapy jell. After the chemical is placed in the drain pipe, it will effervesce (bubble, hiss, and foam) violently and produce considerable heat. Do not use a plunger to hasten the removal of the grease or other accumulation, but allow the chemical sufficient time to dissolve the foreign matter.

CAUTION: The drain-cleaning chemicals must be handled with care to avoid getting the solution on your hands, arms, and face, because they are extremely caustic. Also avoid splashing the chemicals on clothes, wood, painted surfaces, or aluminum. If this happens accidentally, flush the affected part with cold water, then immediately apply vinegar, and finally rinse with cold water.

A chemical cleaner should not be used in drain pipes that are completely clogged. It is necessary to have a slight flow to carry the chemical down to the point of obstruction, because it must be in contact with the stoppage to be effective. Pouring the chemical into a sink drain merely lets most of it settle in the trap. The best method is to remove the trap and insert the

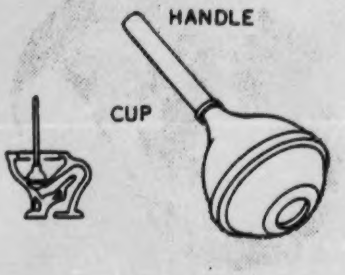


Figure 5-19. Force cup.

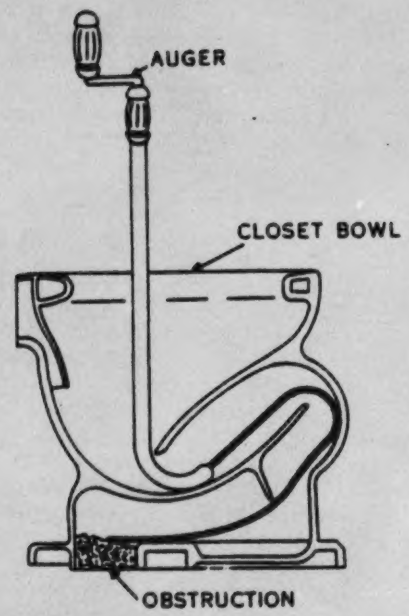


Figure 5-20. Using a closet auger to clear a water closet trap.

chemical in the pipe beyond the trap as indicated in figure 5-17.

Use about a quarter of a can of chemical, and at intervals wash it down the pipe with about a quart of water. Replace the trap, and after about 15 minutes check to see if the water drains away faster. Sometimes repeated chemical treatments are necessary to open the line. When good drainage is obtained, flush the pipe with scalding water for about 5 minutes.

**Opening Clogged Traps.** As you can see in figure 5-18, traps fitted with cleanout plugs are easily opened. To open the trap, remove the cleanout plug, and pull the contents through the cleanout hole with a bent wire. Flush the trap with hot water before you replace the cleanout plug. Traps that do not have a cleanout plug are a little more difficult to open. Often chemicals, force cups, or sink snakes are required to remove the more stubborn types of stoppages. If all the above operations fail, you may have to remove the trap and reverse-flush it with water to remove the stoppage.

Minor stoppages of the closet trap can be cleared with a force cup as indicated in figure 5-19. The more stubborn types of stoppage are removed with a tool called a closet auger, whose operation is illustrated in figure 5-20. The cane-shaped tube with a coiled spring snake inside is equipped with a handle for rotating the coiled hook on the end of the snake. To insert the closet auger into the trap of the water closet, first retract the coiled spring all the way up into the canelike curve of the closet auger. Hook the cane end, with its projecting hook, into the trap, as shown in figure 5-20. Begin turning the handle, to rotate the coiled spring, as it is pushed down into the trap of the water closet. Rotate the handle continuously until the snake reaches the obstruction in the bowl. Turn the handle slowly until the obstruction is caught on the coiled hook of the closet auger. Continue rotating the handle and pull back at the same time to bring the obstruction up into the water closet so you can remove it by hand. Never assume that the water closet is clear after one object is removed. Insert the closet auger a second time and repeat the operation until the closet auger will pass down into the closet bend and branch. Withdraw the closet auger. Put several large wads of toilet paper in the water closet and flush them through the fixture to make sure that it is completely open.

If you are not able to remove the stoppage in the water closet trap with the closet auger, you may have to remove the water closet and turn it upside down to remove the stoppage. If the stoppage is beyond the water closet trap, remove the water closet and run a drain auger down the drain. Figure 5-21 illustrates a typical power-driven auger used for clearing 2- to 4-inch drains.

**Exercises (256):**

1. What should be done after a stoppage is cleared in a waste line?

2. What simple tool is often used to clear a sink or lavatory drain?

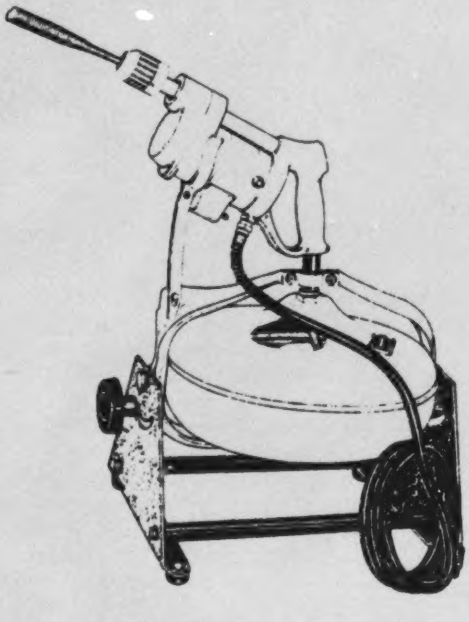


Figure 5-21. Power-driven auger for building drains.

3. What should be done if you accidentally spill a chemical drain cleaner on a part of your body?

4. What tool should be used to remove a minor stoppage from a closet trap?

5. What tool is used to remove stubborn obstructions from water closet traps?

### 5-6. Maintenance of Individual Waste Systems

Individual waste systems should be inspected periodically for efficient operation. Too much sludge in the septic tank will interfere with the bacterial action, which, in turn, will create drainage bed problems.

**257. Given a problem situation related to an individual waste system, solve the problem.**

**Maintenance of Septic Tanks and Disposal Beds.** The septic tank is simple in operation. Building sewage flows into a tight nonleaching tank and is detained there long enough for large solids to settle. The solid matter settles to the bottom of the tank and partially decomposes, producing liquids and gases. The undigested solids form a residue of sludge in the bottom of the tank. Some 40 to 60 percent of the incoming suspended solids are retained, becoming sludge that has to be removed periodically. The remaining solids are carried off suspended in the effluent. Periodic inspections are necessary to prevent health hazards. Inspections should be performed at periods of high flow and as frequently as required by tank size and population load, or at least every 6 months.

The tank inlet and outlet should be checked to see if they are free of stoppages and any accumulation should be removed immediately and disposed of by burying.

The depth of sludge should be checked by using a gage. If the sludge is one-fourth the depth of the septic tank, it should be pumped.

*Pumping septic tanks.* There are several types of pumping equipment used to pump septic tanks. Usually a truck with a large tank equipped with a centrifugal pump is used. The cover should be removed from the septic tank during the cleaning operation. With the cover removed, you can employ the aid of a water hose to break up the scum and sludge for easy removal. After you have pumped the tank, replace the tank cover making sure to have a gastight and watertight seal.

*Replacing disposal beds.* When septic tanks are not maintained, the sludge and scum will flow into the drainage bed, thereby creating problems. The sludge and scum will clog the openings in the drainage pipe. When this occurs, the pipes will have to be replaced. To replace the drainage bed, dig up the old system and replace it with a new one, following the procedures outlined in paragraph 1-3 of this volume.

**Exercises (257):**

1. *Problem Situation:* You are Sergeant Jones in charge of a three-man plumbing crew. You receive a call from the base dog kennel that the sewer is not operating properly. The sink and commode are not working normally. You make an inspection and find that the sludge in the septic tank is three-fourths full. What will you do to solve the problem?

2. What percent of the solids that flow into the septic tank will become sludge?

3. What equipment is used to pump septic tanks?

4. What happens if the sludge and scum is allowed to enter the drainage bed pipes?

# GLOSSARY

**Air Gap**—The unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet supplying water to a tank, plumbing fixture, or other device and the flood-level rim of the receptacle.

**Area Drain**—A receptacle designed to collect surface or rain water from an open area.

**Backflow**—The flowing back of polluted water from a plumbing fixture into a potable water supply pipe due generally to a minus pressure in the supply pipe.

**Backflow Connection**—Any arrangement whereby backflow can occur.

**Backflow Preventer**—A device to prevent backflow into the potable water system.

**Back Siphonage**—The flowing back of used, contaminated, or polluted water from a plumbing fixture.

**Battery of Fixtures**—Any group of two or more similar adjacent fixtures which discharge into a common horizontal waste or soil branch.

**Boiler Blow-Off**—An outlet on a boiler to permit emptying or discharge of sediment.

**Branch**—Any horizontal part of the pipe system other than a main, riser, or stack.

**Branch Vent**—A vent connecting one or more individual vents with a vent stack or vent.

**Building Air System**—A piping system containing air under pressure. The air pressure is normally used to operate controls, devices, and instruments.

**Building (House) Drain**—The part of the lowest piping of a drainage system which receives the discharge from soil, waste, and other drainage pipe inside the building and conveys it to the building (house) sewer beginning a minimum of 3 feet outside the building wall.

**Building (House) Sewer**—The part of the horizontal piping of a drainage system which extends from the end of the building drain. It receives the discharge of the building drain and conveys it to a public sewer, private sewer, individual sewage-disposal system, or other point of disposal.

**Building Storm Drain**—A building drain used for conveying rain water, surface water, ground water, or subsurface water to a building sewer, extending to a point not less than 3 feet outside the building foundation.

**Building Storm Sewer**—The extension from the building storm drain to the public storm sewer, combined sewer, or other point of disposal.

**Building Subdrain**—That portion of a drainage system which cannot drain by gravity into the building sewer.

**Building Trap**—A trap installed in the outlet end of the building drain. Its function is to prevent circulation of air between the drainage system of the building and the building sewer.

**Circuit Vent**—A branch vent that serves two or more traps and extends from in front of the last fixture connection of a horizontal branch to the vent stack.

**Code**—Regulations and amendments which the administrative authority having jurisdiction may lawfully adopt.

**Combination Waste and Vent System**—A system of water piping to which one or more sinks or floor drains are horizontally wet vented by means of a common waste and vent pipe.

**Combined Building Sewer**—A building sewer which receives both storm water and sewage.

**Common Vent**—A vent connecting at the junction of two fixture drains and serving as a vent for both fixtures.

**Continuous Vent**—A vertical vent that is a continuation of the drain to which it connects.

**Continuous Waste**—A drain from a combination fixture, or from two or three fixtures in combination, connected to a single trap.

**Cross-Connection**—Any connection between two otherwise separate piping systems, one of which contains potable water and the other water of questionable safety, whereby water may flow from one system to the other, the direction of flow depending on the pressure differential between the two systems.

**Dead End**—A branch leading from a soil, waste, or vent pipe, building drain, or building sewer which is terminated at a developed length of 2 feet or more by means of a plug or other fitting.

**Developed Length**—The full length of a pipe, measured along the center line of pipe and fittings.

**Double Offset**—Two changes of direction installed in succession or series in continuous pipe.

**Drain**—Any pipe which carries waste water or waterborne waste in a building drainage system.

**Drainage System**—A drainage system (drainage piping) includes all the piping within public or private premises which conveys sewage, rain water, or other liquid wastes to a legal point of disposal. It does not include the mains of a public sewer system of a private or public sewage-treatment or disposal plant.

**Durham System**—A term used to describe soil or waste systems where all piping is of threaded pipe, tubing, or other such rigid construction, using recessed drainage fittings to correspond to the types of piping.

**Effective Opening**—The minimum cross-sectional area at the point of water-supply discharge, measured or expressed in terms of (1) diameter of a circle or (2) the diameter of a circle of equivalent cross-sectional area if the opening is not circular. (This is applicable to air gap.)

**Fixture Branch**—A pipe connecting several fixtures.

**Fixture Drain**—The drain from the trap of a fixture to the junction of that drain with any other drain pipe.

**Fixture Supply**—A water-supply pipe connecting the fixture with the fixture branch.

**Fixture Unit**—A quantity in terms of which the load-producing effects on the plumbing system of all different kinds of plumbing fixtures are expressed on the same arbitrarily chosen scale.

**Fixture Unit Flow Rate**—The total discharge flow in gpm of a single fixture divided by 7.5. This figure is the flow rate of that particular fixture. Fixtures are rated as multiples of this unit of flow.

**Flood Level Rim**—The top edge of the receptacle from which water overflows.

**Flush Valve**—A device located at the bottom of the tank for the purpose of flushing water closets and similar fixtures.

**Flushometer Valve**—A device which discharges a predetermined quantity of water to fixtures for flushing purposes and is actuated by direct pressure.

**Grade (Slope) (Fall)**—The slope or fall of a line of pipe from horizontal. In drainage it is usually expressed as the fall in a fraction of an inch per foot length of pipe.

**Indirect Waste Pipe**—A pipe that does not connect directly with the drainage system but conveys liquid wastes by discharging into a plumbing fixture or receptacle which is directly connected to the drainage system.

**Individual Vent**—A pipe which is installed to vent a fixture trap and which connects with the vent system above the fixture served, or terminates in the open air.

**Industrial Wastes**—Liquid wastes which result from the processes employed in industrial establishments and which are free of fecal matter.

**Interceptor**—A device designed and installed to separate and retain hazardous or undesirable matter from normal wastes and permit normal sewage or liquid wastes to discharge into the disposal terminal by gravity. (Grease interceptor, catch basin.)

**Leader (Downspout)**—The water conductor from the roof to the building storm drain, combined building sewer, or other means of disposal.

**Liquid Waste**—The discharge from any fixture or appliance connected with a plumbing system which does not receive fecal matter.

**Load Factor**—The percentage of the total connected fixture-unit flow rate which is likely to occur at any point in the drainage system.

**Local Ventilating Pipe**—A pipe on the fixture side of the trap through which vapor or foul air is removed from a room or fixture.

**Loop Vent**—The same as a circuit vent, except that it loops back and connects with a stack vent instead of vent stack.

**Main**—The principal artery of the system to which branches may be connected.

**Main Sewer**—Another name for public sewer.

**Main Vent**—The principal artery of the venting system to which vent branches may be connected.

**Offset**—A combination of elbows or bends which brings one section of the pipe out of line into a line parallel with the other section.

**Pitch**—Another term for grade.

**Plumbing Appurtenance**—A manufactured device, or a prefabricated assembly of component parts, which is added to the basic piping system and plumbing fixtures. An appurtenance demands no additional water supply, nor does it add any discharge load to a fixture or the drainage system. It performs some useful function in the operation, maintenance, servicing, economy, or safety of the plumbing system.

**Plumbing Fixture**—Installed receptacles, devices, or appliances which are supplied by water or which receive or discharge liquid or liquid-borne waste into the drainage system.

**Potable Water**—Water which is satisfactory for drinking, culinary, and domestic purposes and which meets the requirements of the health authority having jurisdiction.

**Private Sewer**—A sewer privately owned and not directly controlled by public authority.

**Public Sewer**—A common sewer circuitry controlled by public authority.

**Relief Vent**—A vent whose primary function is to provide circulation of air between drainage and vent systems.

**Return Offset**—A double offset installed to return the pipe to its original alinement.

**Revent Pipe (Sometimes Called An Individual Vent)**—The part of a vent line which connects directly with an individual waste or group of wastes, underneath or back of the fixture, and which extends either to the main or branch vent pipe.

**Rim**—Unobstructed open edge of a fixture.

**Riser**—A waste-supply pipe which extends vertically one full story or more to convey water to branches or fixtures.

**Roof Drain**—A drain installed to receive water collecting on the surface of a roof and to discharge it into the leader (downspout).

**Roughing-In**—The installation of all parts of the plumbing system which can be completed prior to the installation of fixtures. This includes drainage, water supply, and vent piping, and the necessary fixture supports.

**Sanitary Sewer**—A pipe which carries sewage but does not carry storm, surface, and ground water.

**Separator**—Another name for interceptor.

**Septic Tank**—A watertight receptacle which receives the discharge of a drainage system or part thereof. It is constructed to separate solids from the liquid, digest organic matter through a period of detention, and allow the liquids to discharge into the soil outside the tank through a system of open-joint or perforated piping or a disposal pit.

**Sewage**—Any liquid waste containing animal, vegetable, or chemical matter in suspension or solution.

**Side Vent**—A vent connecting to the drain pipe through a fitting at an angle not greater than 45° to the vertical.

**Soil Piping**—Any pipe which conveys the discharge of water closets, urinals, or fixtures having similar functions, with or without the discharge from other fixtures, to the buidling drain or building sewer.

**Stack**—The main vertical assembly of soil, waste, or vent piping.

**Stack Group**—A term applied to the location of fixtures in relation to the stack so that, by means of proper fittings, vents may be reduced to a minimum.

**Stack (Sod) Venting**—A method of venting a fixture or fixtures through the soil or waste stack.

**Storm Sewer**—A sewer used for conveying rainwater, surface water, cooling water, or similar liquid wastes, exclusive of sewage and industrial waste.

**Subsoil Drain**—A drain which receives only subsurface water and conveys it to a place of disposal.

**Sump**—A tank or pit which receives sewage or liquid waste. It is located below the normal grade of the gravity system, and therefore must be emptied by pumping.

**Support**—Support hangers and devices for supporting and securing pipe and fixtures to walls, ceilings, floors, or structural members.

**Trap**—A fitting or device constructed to provide a liquid seal which will prevent the back passage of air without materially affecting the flow of sewage or waste water through it.

**Trap Seal**—The maximum vertical depth of liquid that a trap will retain, measured between the crown weir and the top of the dip of the trap.

**Tucker Connection**—A special sleeve coupling with female thread on one end and a deep bell on the other.

**Unsanitary**—Contrary to sanitary principles: injurious to health.

**Vent Stack**—Vertical vent pipe installed primarily to provide circulation of air to and from any part of the drainage system.

**Vent System**—A pipe or pipes installed to provide a flow of air to or from a drainage system or to provide a flow of air within the system to protect trap seals from siphonage and back pressure.

**Waste Pipe**—Pipe which conveys only liquid waste, free of fecal matter.

**Water-Distribution Pipe**—Pipe which conveys water from the water-service pipe to the plumbing fixtures and other water outlets.

**Water Main**—A water-supply pipe for public or community use (street main).

**Water-Service Pipe**—The pipe from the water main or other source of water supply to the building served. (Service line: service pipe.)

**Water-Supply System**—The water supply system of a building or premises consists of the water-service pipe, the water-distributing pipes, and the necessary connecting pipes, fittings, control valves, and all appurtenances in or adjacent to the building or premises.

**Wet Vent**—A vent which also receives the discharge from wastes other than water closets.

**Yoke Vent**—A pipe connecting upward from a soil or waste stack to a vent stack for the purpose of preventing pressure changes in the stacks.

# Answers for Exercises

CHAPTER 1

**Reference:**
200 - 1.

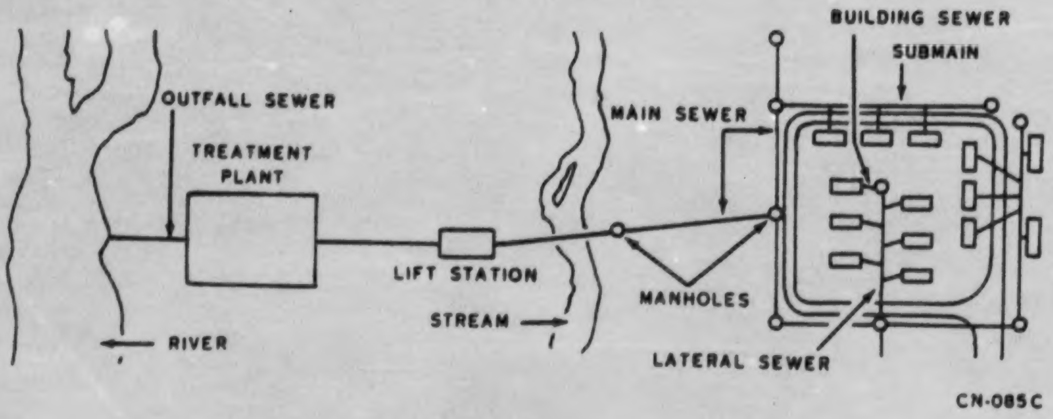

BUILDING SEWER
SUBMAIN
OUTFALL SEWER
MAIN SEWER
TREATMENT PLANT
LIFT STATION
MANHOLES
STREAM
RIVER
LATERAL SEWER
CN-085C

Figure 1. Answer for objective 200, exercise 1.

201 - 1. X
201 - 2. X
201 - 3. ___
201 - 4. X
201 - 5. ___
201 - 6. X

202 - 1. ✓
202 - 2. ___
202 - 3. ✓
202 - 4. ✓
202 - 5. ___
202 - 6. ✓
202 - 7. ___

203 - 1. ___
203 - 2. C
203 - 3. C
203 - 4. C
203 - 5. ___

204 - 1. T
204 - 2. ___
204 - 3. T
204 - 4. ___
204 - 5. T
204 - 6. T
204 - 7. ___
204 - 8. T

205 - a. 2
205 - b. 1
205 - c. 4
205 - d. 5
205 - e. 3

206 - 1. C
206 - 2. C
206 - 3. ___
206 - 4. ___
206 - 5. C
206 - 6. C
206 - 7. C
206 - 8. ___

207 - 1. T
207 - 2. ___

207 - 3. T
207 - 4. T
207 - 5. T
207 - 6. ____
207 - 7. T
207 - 8. ____
207 - 9. ____
207 -10. T

## CHAPTER 2

208 - 1. Wood, steel, masonry.
208 - 2. Box, frame.
208 - 3. Frame.
208 - 4. Some type of masonary construction.
209 - 5. Metal.

209 - 1. C
209 - 2. C
209 - 3. ____
209 - 4. C

210 - 1. T
210 - 2. T
210 - 3. ____
210 - 4. T

211 - 1. a,c.
211 - 2. b,d,e,f,g.
211 - 3. e,f,g.

212 - a. 2,3,4,5.
212 - b. 1,3.

213 - 1.
213 - 2.
213 - 3. ____
213 - 4.

214 - 1. C
214 - 2. ____
214 - 3. C
214 - 4. ____
214 - 5. C

215 - 1. X
215 - 2. X
215 - 3. ____
215 - 4. X
215 - 5. X

216 - 1.
216 - 2. ____
216 - 3.
216 - 4. ____

217 - 1. You must first calculate the maximum discharge of water and waste materials into it.
217 - 2. 7½ gallons.
217 - 3. 19.

218 - 1.
218 - 2. ____
218 - 3.
218 - 4. ____

219 - a. Soil stack.
219 - b. Vent stack.
219 - c. Stack.
219 - d. Stack vent.
219 - e. Waste stack.

220 - 1. ✓
220 - 2. ✓
220 - 3. ____
220 - 4. ____

221 - 1. Test tee.
221 - 2. C
221 - 3. ____
221 - 4. C

222 - 1. X
222 - 2. X
222 - 3. ____
222 - 4. X

223 - 1. T
223 - 2. T
223 - 3. ____
223 - 4. T

224 - 1. Main.
224 - 2. Unit.
224 - 3. Loop.
224 - 4. Relief.

225 - 1. c
225 - 2. a
225 - 3. b

## CHAPTER 3

226 - 1. a,b.
226 - 2. a,b.
226 - 3. d
226 - 4. c

227 - 1. C
227 - 2. ____
227 - 3. C
237 - 4. C

228 - 1. (a) Wash down.
228 - 2. 2 inches.
228 - 3. 1½ inches.
228 - 4. To have a more efficient operation.

229 - 1. T
229 - 2. ____
229 - 3. T

230 - 1. ✓
230 - 2. ____
230 - 3. ✓
230 - 4. ✓

231 - 1. a,b,d.

232 - 1. T
232 - 2. ____
232 - 3. ____

233 - 1. ½ inch.
233 - 2. 2 inch.
233 - 3. Waterproofing the walls and floor.
233 - 4. To prevent corrosive action caused by electrolysis.

234 - 1. T
234 - 2. T
234 - 3. T
234 - 4. ____

235 - 1. b, c, e, f.
235 - 2. Plastics have different characteristics and may not bond properly.

236 - 1. √
236 - 2. √
236 - 3. ___
236 - 4. √

237 - 1. C
237 - 2. I
237 - 3. I
237 - 4. C
237 - 5. I
237 - 6. C
237 - 7. C

238 - 1. Flat, mushroom, and sloped.
238 - 2. 1½ to 2 times.
238 - 3. Provisions for overflow.

## CHAPTER 4

239 - 1. √
239 - 2. ___
239 - 3. √
239 - 4. √
239 - 5. ___

240 - 1. Bluish tinge.
240 - 2. Liquified pertroleum furnace.
240 - 3. 3/4 to 1 inch.
240 - 4. 3 pounds.
240 - 5. Joint runner.
240 - 6. 5°.

241 - 1. One-fourth turn.
241 - 2. The burr will hinder the flow of liquids and gases.
241 - 3. Clockwise.

242 - 1. b
242 - 2. a
242 - 3. c

243 - 1. The pipe should be reamed to remove the burr.
243 - 2. A stiff wire brush.
243 - 3. 3 to 3 1/4 turns.

244 - 1. T
244 - 2. ___
244 - 3. T

245 - 1. C
245 - 2. C
245 - 3. ___
245 - 4. C

246 - 1. Two suitable lead-lined sleeves.
246 - 2. By hand.

247 - 1. √
247 - 2. ___
247 - 3. √
247 - 4. √

## CHAPTER 5

248 - 1. b
248 - 2. c
248 - 3. d
248 - 4. a

249 - 1. Recalk the joint.
249 - 2. Pickout iron.
249 - 3. Insertable session joint.

250 - 1. Tucker connection.
250 - 2. Union.
250 - 3. Support and brace the piping.

251 - 1. C
251 - 2. ___
251 - 3. C
251 - 4. C

252 - 1. T
252 - 2. F
252 - 3. T
252 - 4. T
252 - 5. T

253 - 1. C
253 - 2. ___
253 - 3. C
253 - 4. ___
253 - 5. C
253 - 6. C

254 - 1. 3/4 inch.
254 - 2. At the cleanout plug.
254 - 3. Split roller head and spearhead.

255 - 1. √
255 - 2. √
255 - 3. ___
255 - 4. √
255 - 5. √

256 - 1. The waste line should be flushed with hot water.
256 - 2. The vacuum plunger.
256 - 3. You should flush the area with cold water, then immediately apply vinegar, and rinse with cold water.
256 - 4. A force cup.
256 - 5. A closet auger.

257 - 1. Pump and clean the septic tank.
257 - 2. 40 to 60 percent.
257 - 3. Usually a large truck with a centrifugal pump.
257 - 4. The sludge and scum will clog the opening in the pipes.

150

**STOP–** **1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.** **2. USE NUMBER 1 OR NUMBER 2 PENCIL.**

55255 02 24

# EXTENSION COURSE INSTITUTE
# VOLUME REVIEW EXERCISE

## WASTE SYSTEMS

Carefully read the following:

*DO'S:*

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that numerical sequence on answer sheet alternates across from column to column.
3. Use a medium sharp #1 or #2 black lead pencil for marking answer sheet.
4. Circle the correct answer in this test booklet. After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

*DON'TS:*

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #1 or #2 black lead pencil.

*NOTE:* NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed.* Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

156

## Multiple Choice

1. (200) Which part of the sewage system receives discharge from building sewers and carries it to the submain?

   a. Leader.
   b. Lateral.
   c. Extension.
   d. Waste pipe.

2. (200) Which part of the sewer system receives discharge from the treatment plant and carries it to the place of final disposal?

   a. Outfall.
   b. Dropoff.
   c. Submain.
   d. Offslope.

3. (200) What item should be installed at changes in invert elevation?

   a. Manhole.
   b. Half section.
   c. Secondary leader.
   d. Primary lift pump.

4. (201) What is the minimum rate of fall for a 3-inch building sewer?

   a. 1/4 inch per foot.
   b. 1/2 inch per foot.
   c. 1/4 inch per 3-foot section.
   d. 1/2 inch per 3-foot section.

5. (201) What is the minimum flow rate slope for main and submain sewers?

   a. 1 foot per second.
   b. 2 feet per second.
   c. 1 foot per 3-foot section.
   d. 2 feet per 3-foot section.

6. (201) What will result when a pipe slope is in excess of the specified rate of fall?

   a. Damage to lift station.
   b. Gaseous vacuum is created.
   c. Water will run away from the solids.
   d. Added pressure will cause back blockage.

7. (202) The minimum safe distance from a ditch excavation that dirt should be piled away from the edge is

   a. 12 inches.
   b. 24 inches.
   c. 36 inches.
   d. 48 inches.

8. (202) What is the maximum safe distance between access ladders placed in a ditch 6 feet deep?

   a. 25 feet.
   b. 50 feet.
   c. 75 feet.
   d. 100 feet.

9. (203) What device should be used to connect a house sewer to a main sewer?

   a. Saddle.
   b. Reducer.
   c. Thimble.
   d. Increaser.

10. (204) What materials should be used for joints in a tile sewer line?

    a. Oakum and mortar.
    b. Asphalt and hub clamp.
    c. Treated felt and sealer.
    d. Bituminous compound and asbestos wick.

11. (205) To what minimum depth above a sewer pipe should a ditch be tamped when backfilling?

a. 6 inches.
b. 12 inches.
c. 18 inches.
d. 24 inches.

12. (206) Which of the following will not be reduced to a liquid form in a septic tank?

a. Animal solids.
b. Vegetable solids.
c. Leather substance.
d. Mineral substance.

13. (206) Which type of bacteria breaks solids down to liquids in a septic tank?

a. Hemocyte.
b. Ctenophore.
c. Pulvinate.
d. Anaerobic.

14. (206) What should be installed in a septic tank to reduce the scum agitation?

a. Baffle boards.
b. Reverb panels.
c. Siphon chamber.
d. Chemical compound.

15. (206) How is the trap in a bell siphon resealed?

a. By a pressurized flapper valve.
b. By the pressure of drainage flow.
c. By the anti-sludge accumulator valve.
d. By the last portion of the drainage flow.

16. (207) What type of test should be made to determine the length of the drainage lines when constructing a drainage bed?

a. Saturation.
b. Geotropism.
c. Percolation.
d. Bactericidal.

17. (208) What are the two types of construction for wood buildings?

a. Open and box.
b. Box and frame.
c. Sealed and open.
d. Frame and sealed.

18. (208) What type of piping system should be used for supply lines in buildings with concrete walls?

a. Exposed.
b. Internal.
c. Low pressure.
d. High pressure.

19. (209) Which type of information is found on a specification sheet?

a. Rough-in dimensions.
b. Exact model of fixtures.
c. Routing of supply lines.
d. Location of structural openings.

20. (210) How should holes be made in a line of wall studs to install a water supply pipe?

a. Notch fixture side.
b. Drill in the center.
c. Drill on fixture side.
d. Notch opposite fixture.

21. (210) What governs the actual cutting of an opening?

a. Blueprint.
b. Appliances.
c. Engineer drawing.
d. Type of material.

22. (211) When making a square hole, what should be used to mark the grain of the cut?

a. Awl.
b. Knife.
c. Miter saw.
d. Wood chisel.

23. (212) What should be used to cut openings for pipe in solid masonry structures when power tools are not available?

a. Star drill and brace.
b. Swing brace and drill.
c. Star drill and hammer.
d. Cold chisel and hammer.

24. (213) What should be used to remove a burr after a hole has been put in a metal building with a center punch?

a. Reamer.
b. Flat file.
c. Sandpaper.
d. Half-round file.

25. (214) Which method should be used to reinforce a beam that has been overcut?

a. Joist bracing.
b. Wedged block of wood.
c. Steel plates and bolts.
d. Iron brace and lay screws.

26. (215) How should horizontal cast-iron pipe be suspended?

a. By iron rings at 5-foot intervals.
b. By iron rings at 10-foot intervals.
c. By galvanized steel hangers at 5-foot intervals.
d. By galvanized steel hangers at 10-foot intervals.

27. (215) What is the maximum interval for supports on 1-inch vertical copper pipe?

a. 2 feet.
b. 4 feet.
c. 6 feet.
d. 8 feet.

28. (215) Which of the following should be used to support plastic pipe?

a. Plastic straps.
b. Wood headers.
c. Perforated steel tape.
d. Insulated wire hangers.

29. (216) What determines the number of stacks that are required for a building waste system?

a. Combination wye.
b. Grade and alignment.
c. Location of fixtures.
d. Location of cleanout plug.

30. (217) How much water would an ordinary lavatory discharge in a 1-minute interval?

a. 3 1/2 gallons.
b. 7 1/2 gallons.
c. 2 1/2 cubic feet.
d. 4 1/2 cubic feet.

31. (218) What unit should be installed in a sanitary tee to provide for future use?

a. Square offset.
b. Cleanout plug.
c. Double offset.
d. Secondary stack vent.

32. (219) What is the minimum diameter for pipe used as a soil stack?

a. 1 1/2 inches.
b. 2 inches.
c. 2 1/2 inches.
d. 3 inches.

33. (219) Which type of stack is a vertical pipe that provides a circulation of air through the drainage system?

a. Vent.
b. Waste.
c. Relief.
d. Bypass.

34. (219) The extension of a soil or waste stack above the highest fixture or branch inlet is called

a. an overset.
b. a cap system.
c. a stack vent.
d. an aerator section.

35. (220) What is the preferred diameter of pipe that can be used for a soil stack?

a. 1 1/2 inches.
b. 2 inches.
c. 3 inches.
d. 4 inches.

36. (221) What should be installed if no provisions were made for cleaning the drain at the stack base?

a. Test tee.
b. Relief wye.
c. Cleanout wye.
d. Sanitary tee.

37. (222) Where should vertical stacks in multi-story construction be supported?

a. At each branch opening.
b. At every connection or joint.
c. As each 4-foot section is installed.
d. As it passes through each floor level.

38. (223) What is the minimum distance that a vent terminal should project through the roof?

a. 3 inches.
b. 6 inches.
c. 9 inches.
d. 12 inches.

39. (223) What is used to make a watertight roof opening around a stack?

a. Shingles.
b. Flashing.
c. High lead.
d. Asphalt seal.

40. (224) What type of vent is installed to protect two fixture traps side by side?

a. Unit.
b. Loop.
c. Relief.
d. Individual.

41. (224) What is the maximum number of lavatories or other fixtures permitted on any one vent circuit?

a. 4.
b. 6.
c. 8.
d. 10.

42. (224) Which type of vent dissipates negative pressure by introducing air and prevents siphonage of the fixture traps in its path?

a. Wet.
b. Back.
c. Flow.
d. Relief.

43. (226) What is the direct result of capillary action in a trap?

a. Evaporation.
b. Back pressure.
c. Loss of water seal.
d. Indirect siphoning.

44. (226) What is the smallest pipe diameter that should be used for a main vent?

a. 3/4 inch.
b. 1 1/4 inches.
c. 2 1/2 inches.
d. 3 1/2 inches.

45. (227) What is the recommended type of fitting for making a final joint in a loop of pipe?

a. Bell coupling.
b. Tapered sleeve.
c. Extra-long threaded nipple.
d. Tucker connection.

46. (227) How much fall per foot should horizontal vent pipes have?

a. 1/4 inch.
b. 1/2 inch.
c. 3/4 inch.
d. 1 inch.

47. (228) What is the minimum size of waste pipe used for draining an individual urinal?

a. 1/2 inch.
b. 1 inch.
c. 1 1/2 inches.
d. 2 inches.

48. (228) Vents for a battery of urinals which have a siphon-jet flushing action should be installed

a. individually vented.
b. dual vented.
c. relief vented.
d. low-pressure circuit vented.

49. (228) When is circuit venting of pedestal type urinals permitted?

a. When there are more than 8 urinals on a loop.
b. When urinals discharge directly into a vertical soil or waste pipe.
c. When urinals discharge directly into a horizontal waste pipe.
d. When the trap is connected into a fitting on a vertical waste pipe.

50. (229) The distance above the floor that the lip of a wall-hung urinal should be is

a. 18 to 21 inches.
b. 22 to 25 inches.
c. 26 to 29 inches.
d. 30 to 33 inches.

51. (230) Why are screw-type drainage fittings preferred over straight threaded fittings for urinal drains?

a. Inlets are tapped with a pitch of 1/4 inch per foot.
b. Inlets are tapped with a pitch of 1/2 inch per foot.
c. Outlets are tapered with a pitch of 3/4 inch per foot.
d. Outlets are tapered with a pitch of 1/2 inch per foot.

52. (231) How much, if any, increase in the size of a waste pipe is necessary when a shower head is installed over a bathtub?

a. 1/4 inch.
b. 1/2 inch.
c. 1 inch.
d. none.

53. (231) What are the two types of traps that should be used for a bathtub and shower combination?

a. Drum trap and P-trap.
b. Bell trap and P-trap.
c. Double trap and Bell trap.
d. Drum trap and double trap.

54. (232) The drain inlet for a bathtub should be positioned correctly so that it will

a. fit the Bell trap.
b. fit the tail piece.
c. connect the gooseneck.
d. connect the sanitary tee.

55. (233) What type of fitting should be used for making a connection for a shower dry vent?

a. Bell.
b. Bend.
c. Tucker.
d. Reducer.

56. (234) What type of fitting is imbedded in a concrete slab for attaching a water closet?

a. Protected hub.
b. Closet taper.
c. Sunken trap.
d. Closet bend.

57. (235) Which type of pipe should be used for a water closet drain that is installed in a concrete floor?

a. Cast iron.
b. Galvanized.
c. Vitrified clay.
d. Asbestos cement.

58. (235) Which size copper pipe can be used to replace a 4-inch cast-iron soil branch?

a. 1 inch.
b. 1 1/2 inches.
c. 3 inches.
d. 3 1/2 inches.

59. (236) Water closets are attached to a closet bend using a

a. heel tapping.
b. slip-type collar.
c. reducing collar.
d. flanged collar.

60. (237) Which type of floor drain is normally used with sanitary sewers?

a. Water seal.
b. Check seal.
c. Float seal.
d. Non-water seal.

61. (237) Which situation would require the use of a deep seal trap?

a. On an automatic dishwasher.
b. When a trap has a direct vent.
c. Where a trap can not be vented.
d. On a bathtub and shower combination.

62. (237) What is the smallest diameter of pipe that should be used for floor drain waste lines?

a. 1 inch.
b. 2 inches.
c. 3 inches.
d. 4 inches.

63. (237) To which type of system should a vehicle washrack drain be connected?

a. Storm sewer.
b. French drain.
c. Soaker drain.
d. Sanitary sewer.

64. (238) What type of roof drain should be used on a flat roof where leaves could present a problem?

a. Flat strainer.
b. Wedge strainer.
c. Sloped strainer.
d. Mushroom strainer.

65. (238) The open area of a roof strainer should be larger than the pipe to which it connects by

a. 1/2 to 1 times.
b. 1 1/2 to 2 times.
c. 2 1/2 to 3 times.
d. 3 1/2 to 4 times.

66. (239) What should be done to cast-iron pipe before and after it is cut?

a. Ream it.
b. Sound it.
c. Leak test.
d. Pressure test.

67. (239) What should always be done before attempting to cut cast-iron pipe with a snap cutter?

a. Release the tension.
b. Oil the guide bar.
c. Align the chain.
d. Set the gage.

68. (239) Which would be the best method to cut 1 inch off a section of cast-iron pipe?

a. Grinder.
b. Cable cutter.
c. Hammer and chisel.
d. Hacksaw and adjustable wrench.

69. (240) If you do not have a thermometer, how can you tell when molten lead is ready to pour?

a. When it turns a bluish tinge.
b. When it reaches a cherry red color.
c. As soon as the ingots disappear.
d. As a skin appears on the top.

70. (240) What is apt to happen if molten lead is poured into a wet vertical joint?

a. Joint may split.
b. Lead can splatter.
c. Lead will cool too fast.
d. Joint may have air bubbles.

71. (240) What item is used to direct molten lead into a horizontal joint?

a. Preformed insert.
b. Ruffer edge board.
c. Asbestos joint runner.
d. Split ring connection.

72. (240) Which type of cast-iron pipe joint can absorb vibrations and be deflected up to 5° without leakage or failure?

a. Hot poured.
b. Pressurized.
c. Asphalt seal.
d. Compression.

73. (240) Which tool is required when installing a no-hub joint?

a. Spud wrench.
b. Saddle strap.
c. Torque wrench.
d. Locking collar.

74. (242) What is the minimum number of threads which should extend beyond the head of a die when cutting threads with an adjustable die?

a. 1,
b. 2.
c. 3.
d. 4.

75. (242) Which of the following should be used when cutting clean threads for watertight pipe joints?

a. S. W. grease.
b. Clean solvent.
c. Clear water.
d. Good grade of lard.

76. (242) The number of threads per inch that a 2-inch pipe should have is

a. 7 1/2.
b. 9 1/2.
c. 11 1/2.
d. 13 1/2.

77. (243) What is a bench threader designed to do in addition to threading pipe?

a. Cut and ream.
b. Taper and cut.
c. Strike and ream.
d. Taper and strike.

78. (243) What part of the power-driven bench threader supports the weight of a pipe that extends beyond the end of the machine?

a. Pipe rest.
b. Roller arm.
c. Chuck slide.
d. Striker block.

79. (243) What should be used to remove dirt and chips from the jaw teeth on a threading machine?

a. Solvent.
b. Clean rag.
c. Wire brush.
d. Air pressure.

80. (243) How far should you be able to screw a properly threaded pipe into a fitting by hand?

a. 1 to 1 1/4 turns.
b. 2 to 2 1/4 turns.
c. 3 to 3 1/4 turns.
d. 4 to 4 1/4 turns.

81. (243) When using a power-driven bench threader, how are the die segments released after the threads have been cut?

a. Lift the release lever.
b. Push the release lever.
c. Push the manual stop button.
d. Engage the automatic stop button.

82. (244) The maximum diameter of pipe which can be chucked in the portable power-driven vise stand is

a. 1 inch.
b. 2 inches.
c. 3 inches.
d. 4 inches.

83. (245) Which type threader should be used to cut threads on 6-inch pipe?

a. Geared.
b. Hydraulic.
c. Hydrostatic.
d. Chain-driven.

84. (245) At what angle to the pipe should a hole be drilled to tap threads in the side of a pipe?

a. 30°.
b. 45°.
c. 60°.
d. 90°.

85. (246) What is the usual method for threading copper pipe?

a. By hand.
b. On a power machine.
c. By using a brass die.
d. On the portable vise stand.

86. (247) What is the minimum schedule recommended for plastic pipe which is to be threaded?

a. 40.
b. 60.
c. 80.
d. 100.

87. (248) Which of the following methods is usually used to test a repaired or modified pipe system?

a. Peppermint.
b. Water.
c. Air.
d. Smoke.

88. (248) The point to which a waste system should be filled when performing a water test is

a. 5 feet above the lowest trap.
b. 10 feet above the lowest trap.
c. level with the lowest vent stack opening above the roof.
d. level with the highest vent stack opening above the roof.

89. (248) How much time should be allowed for oakum to swell in pipe joints prior to a water test?

a. 1 to 6 hours.
b. 6 to 12 hours.
c. 12 to 24 hours.
d. 24 to 48 hours.

90. (248) For a positive air test, what psi pressure is used and how long should the system hold it without leakage?

a. 5 pounds per square inch for 15 minutes.
b. 10 pounds per square inch for 25 minutes.
c. 15 pounds per square inch for 30 minutes.
d. 20 pounds per square inch for 40 minutes.

91. (248) Which instrument should be used to indicate pressure when an air test is being made?

a. Pilot tube.
b. Vacuum gage.
c. Mercury gage.
d. Curling tube.

92. (248) What type of test should be used for the final testing of a new waste system after the fixtures and traps have been installed?

a. Smoke.
b. Sealed.
c. Peppermint.
d. Air-intrained.

93. (249) What would be the best method to remove the old lead when repairing a leak in a cast-iron pipe joint?

a. Use a pickout iron.
b. Apply a spreader bar.
c. Apply heat to melt the lead.
d. Use a hammer to tap it loose.

94. (249) What should be done to a pipe when an air test locates a leak in a cast-iron pipe fitting caused by sand holes made during casting?

a. Weld.
b. Braze.
c. Reseal.
d. Replace.

95. (250) What action should be taken when a leak is detected in a threaded pipe joint vent system?

a. Replace the piping.
b. Tighten the joint.
c. Loosen, apply compound, and tighten the joint.
d. Install a pipe union.

96. (250) What should be done before removing a section of piping to repair a vertical pipe run?

a. Support and brace. c. Add Tucker connection.
b. Clean with solvent. d. Install additional casting.

97. (251) What would be the ideal location for a grease trap?

a. Under the fixture. c. Corner of kitchen.
b. Center of kitchen. d. Outside.

98. (252) What is probably the most reliable method for finding the exact location and depth of a buried pipe?

a. Probing. c. Consulting maps.
b. Sounding. d. Using a metallic detector.

99. (252) At what intervals are manholes normally provided on sewer mains?

a. 100 feet. c. 300 feet.
b. 200 feet. d. 400 feet.

100. (252) What is a good safety practice when a person must enter a manhole to inspect a sewer main?

a. Use an air pack. c. Standby truck with lights.
b. Pneumatic equipment. d. Standby man with a rope.

101. (253) What are the two types of maintenance performed on sewer mains?

a. Emergency and annual. c. Recurring and emergency.
b. Routine and semiannual. d. Semiannual and recurring.

102. (253) What is used to guide the rod of a power sewer auger when it is inserted into a man sewer?

a. H-bar. c. O-hook.
b. J-tube. d. C-bracket.

103. (253) How should the rod of a power sewer auger be retrieved?

a. Drum rotating clockwise, feed lever in reverse.
b. Drum rotating clockwise, feed lever in forward.
c. Drum rotating counterclockwise, feed lever in reverse.
d. Drum rotating counterclockwise, feed lever in forward.

104. (253) How many men should be on a power auger crew to safely perform the operation?

a. 2. c. 4.
b. 3. d. 5.

105. (254) Which size flat sewer snake is suitable for use in a 3-inch pipe?

a. 1/4 inch. c. 3/4 inch.
b. 1/2 inch. d. 1 inch.

106. (254) What precaution should be taken when operating an electric sewer auger?

a. Wear rubber boots. c. Make sure the machine is grounded.
b. Make sure the area is dry. d. Wear gloves to install all heads.

107. (255) Which of the following could alter a pipe grade and change the drainage flow?

a. Obstruction. c. Waste overload.
b. Cracked joint. d. Missing pipe support.

108. (256) Which method should be used when a lavatory is completely stopped up?

a. Mechanical. c. Electrical.
b. Hot water. d. Chemicals.

109. (257) When would be the best time to inspect a septic tank?

a. Annually. c. During periods of low flow.
b. During periods of no flow. d. During periods of high flow.

110. (257) When would a septic tank require pumping?

a. When the sludge is 1/8 the depth of the tank.
b. When the sludge is 1/4 the depth of the tank.
c. When the sludge is 1/2 the depth of the tank.
d. When the flow level is obstructed.

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CDC 55255

# PLUMBING SPECIALIST

(AFSC 55255)

Volume 3

*Water Supply Systems and Fixtures*

3-2

Extension Course Institute

Air University

PREPARED BY
DEPARTMENT OF CIVIL ENGINEERING TRAINING
USAF SCHOOL OF APPLIED AEROSPACE SCIENCES (ATC)
SHEPPARD AIR FORCE BASE, TEXAS

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EXTENSION COURSE INSTITUTE, GUNTER AIR FORCE STATION, ALABAMA

THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL
OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES
ON DOCTRINE, POLICY ESSENTIALITY, PROPRIETY, AND QUALITY

# Preface

THIS THIRD volume of CDC 55255, *Plumbing Specialist*, will provide you with the information necessary for you to install and maintain water supply systems and fixtures. You will learn what constitutes a water supply system and how water pipes are assembled. You will learn about roughing-in water supplies and installing fixtures: using copper tubing and brass pipe: insulating and winterizing plumbing systems: installing and maintaining water heaters, dishwashers, steam kettles, sinks, auxiliary plumbing equipment, fire protection systems, and lawn sprinkler systems: and the application of preventive maintenance and corrosion control to plumbing systems.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to USAFSAAS/TCE, Sheppard AFB TX 76311. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

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This volume is valued at 27 hours (9 points).

Material in this volume is technically accurate, adequate, and current as of November 1975.

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**NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.**

# Water Supply Systems and Pipe Assembling

THERE WAS A TIME when a family's water supply consisted of a spring or well. The only thing you had to do was locate a spring or dig a well. But in this day and time, a family's water supply normally consists of a plumbing water supply system. In your job as an Air Force plumber, you will be fabricating these systems. Before you attempt to fabricate a water supply system you should prepare a working drawing. This eliminates guesswork, because the dimensions and materials are determined before the construction begins. As you plan the system, you will formulate ideas on how the various parts of the system should be installed. You must know how to read blueprints, because if you fail to interpret them correctly, you may install piping that is too small to carry the volume of water required, or you may install the piping in the wrong place in the building.

A situation may arise at any time which will necessitate your constructing a temporary water main. This type of main must be designed and constructed to furnish water for varying periods of time during an emergency, and until repairs can be made to an existing main or a permanent line can be installed. Speed in the construction of temporary lines is urgent in most cases of emergency to restore water service to the affected areas. Therefore, it is very important for you to be familiar with the various types of piping and couplings that are used for this type of construction.

Copper tubing is used in water supply systems on some plumbing jobs instead of steel or wrought iron piping. Either hard drawn or annealed copper tubing may be used for service lines in the open, buried underground, or in concrete. Copper tubing may also be used for the waste lines within the building. So, it is also very important for you to know how to fabricate connections of copper tubing.

This chapter covers layout of water supply systems, water supply system requirements, water supply system materials, preparing a bill of materials, installing mains for a water supply, and the assembling of pipe and fittings for temporary water mains. Other subjects covered are the types of copper tubing; types of fittings; cutting, joining, and cleaning copper tubing; and soldering equipment.

## 1-1. Water Supply Systems

The society we live in today thrives on the availability of all things to the members' immediate demand. Individual water barrels are out, and mass distribution systems are in.

Water distribution systems may be simple or complex. Engineering drawings become guides and maps for the plumber. Many systems may be included in the same drawings. Correct interpretation of such maps eliminates errors in determining materials required, systems construction, and design configuration.

**400. Given a single line drawing of an exterior water distribution system, identify its components and provide required information concerning a water distribution system.**

**Exterior Water Distribution System.** Carefully planned water distribution systems resemble a grid. A network of large piping divides the consumer area into subareas. Each subarea is served by a network of smaller piping. Such systems are often referred to as belt or loop systems. There are no dead ends and water can flow to any point in this system from two or more directions. Further, additions to the system will not reduce its functional capability. Figure 1-1 illustrates an exterior water distribution system.

*Components.* Components in water systems vary, depending on the water source, its location in relationship to the user, and water characteristics.

*a.* Pumps. Pumps may be required at Air Force installations to pump water from lakes, reservoirs, or rivers to water treatment plants. After treatment, additional pumping forces water into the mains and storage facilities. In distribution systems booster pumps may be used to increase water pressure. Emergency pumps are used in case of water supply breakdown or to satisfy firefighting requirements. When pumps are installed in a main or service line, they should be connected to the piping by unions or flanges. This permits easy removal of the pumps from the system for maintenance or for replacement.

*b.* Treatment plants. Absolutely pure water is never found in nature. For military use, water must be free of disease-producing organisms, poisons, and excessive amounts of mineral or organic matter. The amount and type of minerals and organic matter contained in the water will affect the design of a water treatment plant. So no two plants will be the same. But they will have the same function of discharging water made as pure as possible.

*c.* Storage tanks. The normal water demand in a community or military installation varies considerably between night and day and for different days of the week. During low demand periods, treated water is stored in storage tanks. Treated water from the storage tank is fed back into the system when the demands exceed the capacity of the supply source or treatment plant. Storage tanks also provide an emergency water source should a failure occur in the system or for firefighting. Storage tanks may be at ground level or higher than the portion of the system they serve. Reservoirs or storage tanks higher than the distribution system maintain the desired pressure in the system.

*d.* Valves. Valves are used in the water distribution system to control the flow of water. The different types of valves include gate valves, pressure-reducing valves, check valves, curb service valves, globe valves, and fire hydrants.

Breaks and leaks can be caused by freezing, ground movement, collision, fire, excessive water pressure, and explosion. Gate valves placed at strategic points in the service must be closed, thereby isolating the damaged area. Services to the undamaged portion of the system will continue without being interrupted.

Globe valves are used in the distribution system on small lines or service lines. They restrict the flow and cannot be used where flow restriction is not needed.

Check valves will prevent reversal of water flow due to loss of pressure. Check valves will also isolate certain sections of the distribution system.

Pressure-reducing valves throttle the flow in pipes to reduce the pressure on the discharge side and keep it constant. They are used for feeding water from a high-pressure to a low-pressure system. If great variations in flow rates are expected, different sizes of pressure-reducing valves will be installed in batteries.

Curb service valves control water distribution to individual buildings or dwellings. These will be used as the need for water to the buildings is determined.

Fire hydrants will be placed in all areas where there is a need for fire protection. Proper operation and use of hydrants is essential to water distribution economy and safety. Every fire hydrant should have a gate valve serving as a positive shutoff in case of damage to the hydrant.

*e.* Piping. Mains and piping are composed of feeder mains, distribution mains, branch or lateral lines, and service lines.

The feeder mains are large pipe which supply distribution mains and storage tanks.

Distribution mains are the pipelines which make up the distribution system and include any lateral or branch lines from which service lines take their supply.

Service lines transport the water from the distribution mains to the various buildings and facilities.

The lateral lines will make the distribution system more effective and efficient by forming a closed loop system.

With the exception of the fire hydrants and some storage tanks, the water distribution system is underground. It is more practical to bury a large portion of the distribution system to protect it from damage from weather and collision.

An important prerequisite for any good operating distribution system is a good set of maps and records. The maps should show the location and size of all valves, pipes, and other components. The records should be an accurate account of all repair and maintenance performed on the system. The maps and

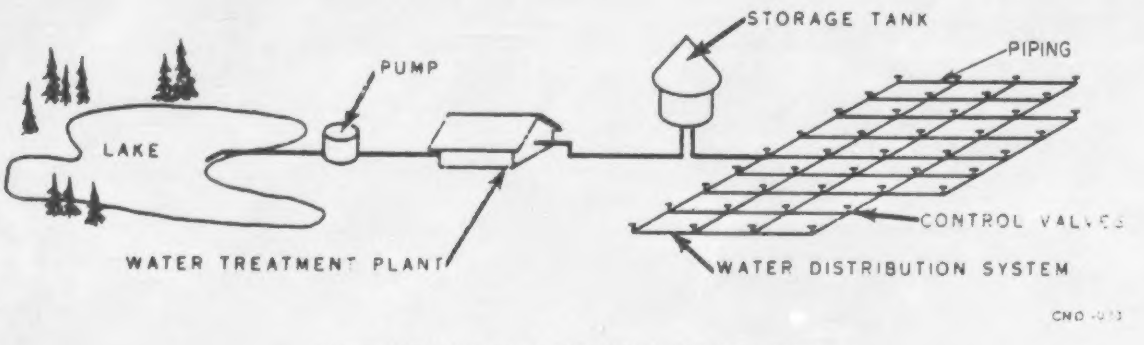

Figure 1-1. Exterior water distribution system.

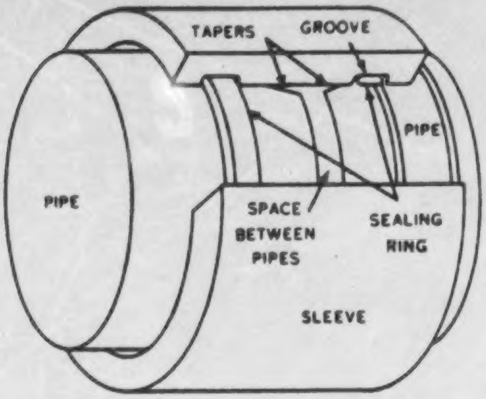

Figure 1-2. Sleeve coupling.

records must be updated each time a repair or maintenance function is performed. Out-of-date records are worthless.

*Factors governing types of water mains to be constructed.* There are two factors that govern water main construction: they are the quantity and quality of water needed.

*a.* Quantity needed. The amount of water needed by an air base will depend on several factors. The effective population, which is all the residents living in the dormitories or in government housing, must be furnished domestic water.

At the beginning of each workday the civilians that work on the base start arriving. These nonresidents help make up the authorized population of the base. Water must be furnished so that each may do his job properly.

Some bases have large hospitals. Hospitals use large amounts of water for bathing patients, mopping floors, kitchen needs, laundries, and other necessities.

The amount of water used by a base will vary both day and night and summer and winter. If a large fire occurs and the firetrucks have to pump water all night, then the base could run low on water supply. This would be called an unusual peak demand.

Firefighting has to be taken into account when the base is first built so that enough water will be on hand if needed. If the base grows, more water towers are needed.

*b.* Quality needed. There are two types of water consumed on a military base. They are domestic and industrial.

(1) Domestic water. Every base must have water that is clear, has an acceptable taste, and is free of bacteria. When water meets these requirements, it is called potable water.

Even though water is potable, there are some things that make it undesirable for domestic uses. These are odors and hardness. Odors come from sour gases in the water or from minerals such as sulphur.

Some water forms a white scale on the walls of water glasses, pipes, and anything where the water can evaporate. This white scale signals the hardness of water. When water contains too much hardness, the water must be softened. This is accomplished in the water treatment plant.

(2) Industrial water. Do you remember seeing water trickling down a large cooling tower? This is industrial water. There are two common uses for industrial water on an Air Force installation: water to furnish Air Force operating equipment, and heated water for sanitation purposes.

Hospitals need pure water for mixing medicines, so they use distilled water. Airplanes use pure water to squirt in the engines for more power. The water they use goes through a demineralizer which removes minerals from the water.

Boilers that heat large amounts of water for laundries use specially treated water to prevent a white scale from covering the insides of the boilers.

*Methods of assembling pipe.* Your job will require that you master several methods of assembling pipe.

*a.* Lead-caulked joints. Lead caulking is used on cast-iron water pipe. The pipe is available in a variety of sizes, lengths, wall thickness, and hub depths. Cast-iron water piping should not be confused with cast-iron soil pipe.

Lead caulking is a method of assembling bell-and-spigot type joints. The spigot end of the pipe is inserted in the bell or hub of the receiving pipe. Oakum is firmly packed into the area between the hub and the spigot end of the pipe with a special tool. The amount of oakum varies with the size and depth of the hub. The remaining hub depth is filled with molten lead, usually 3/4 to 1 inch. The lead is caulked and dressed with specially designed tools. These tools are similar to the tools used to fabricate soil pipe.

*b.* Sulphur joints. Sulphur joints are assembled and poured in the same manner as lead-caulked joints. The oakum is applied, and the sulphur is heated to a liquid state and poured into the joint. No caulking is required on the sulphur joint.

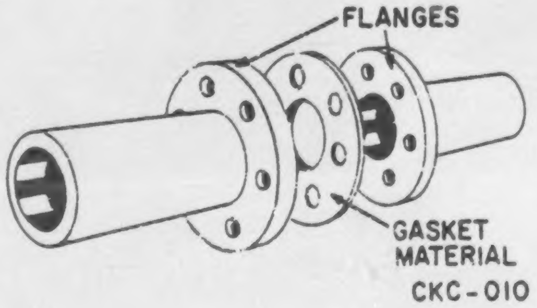

Figure 1-3. Flange fittings.

*c.* Sleeved coupling. A sleeved coupling resembles a can with both ends removed. The cylinder is internally grooved to accommodate rubber O-rings as the pipe is forced into the sleeve. Figure 1-2 shows pipe ends and sleeve assembled.

The sleeve coupling is used to assemble asbestos cement pipe joints. The pipe may be adaptable to cast-iron piping by a lead-caulked joint.

*d.* Screwed joints. A screwed joint is used to assemble steel pipe. It requires an internally threaded fitting to be mated with a matched externally threaded pipe. A pipe compound is applied to the external threads to lubricate them, to aid in forming a seal between the thread surfaces, and to provide an antiseize for easier disassembly. Normally you do not use screwed joints on large pipe.

*e.* Flange. The flange joint, as shown in figure 1-3, has proved its general utility and satisfactory performance. It is used in the installation of pumps, chillers, heat exchangers, and other equipment. The flange itself is molded separately from the pipe. The flange is attached to the pipe by a screwed connection or by welding. A gasket is used between the flanges to form a seal, then bolted securely together to form a watertight or gastight connection.

*f.* Plastic. Plastic pipe can be and often is used for service lines. Some of its advantages are that it is easily connected to copper tubing or pipe, is lightweight, withstands corrosion, is low in cost, and is easy to use. Plastic tubing or pipe is available in sizes from 1/4 to 8 inches in diameter. Plastic pipe is solvent welded, or joined with compression type joints.

*Connecting pipe to pumps.* A variety of pumps are used throughout plumbing systems. Three common methods of connecting pipes to pumps are by unions, flanged connections, and mechanical couplings.

On pumps requiring threaded connections, there is a short nipple screwed into the pump. One side of a union is screwed on the nipple while the other side of the union is screwed on the pipe. The connection is completed by joining the two halves of the union.

**Exercises (400):**

1. Without referring back to the text, identify the components of an exterior water distribution system (fig. 1-4) by writing each component's name at the correct arrow.

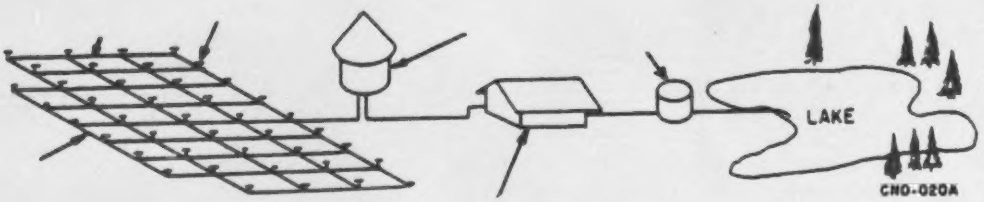

Figure 1-4. Exterior water distribution system (objective 400, exercise 1).

2. What are the two factors that govern the types of water mains to be constructed?

3. What are the two types of water consumed on military bases?

4. What are the three types of connections used to connect pumps to pipe?

**401. Given pertinent questions pertaining to layout, requirements, and materials of water supply systems, supply brief answers.**

**Building Water Supply Systems.** Before installing a building water supply system you need to know how to lay out the system. You need to know how to determine the requirements and the material to be used.

*Layout of water supply systems.* When an architect designs a building, he prepares a set of blueprints. These blueprints are drawn to scale and contain dimensions which enable the various trade workers to do their jobs.

A complete set of blueprints includes a foundation plan; floor plan; roof plan; front, rear, and side elevations; and a plot plan which shows the location of the building on the lot. Specification sheets which indicate the type and quality of materials to be used in the construction are also prepared. The plumber and other tradesmen use these blueprints and specifications to lay out and plan their part of the project.

Blueprints for large buildings include a plan for the rough-in plumbing. A plan for each floor is prepared for multistory buildings.

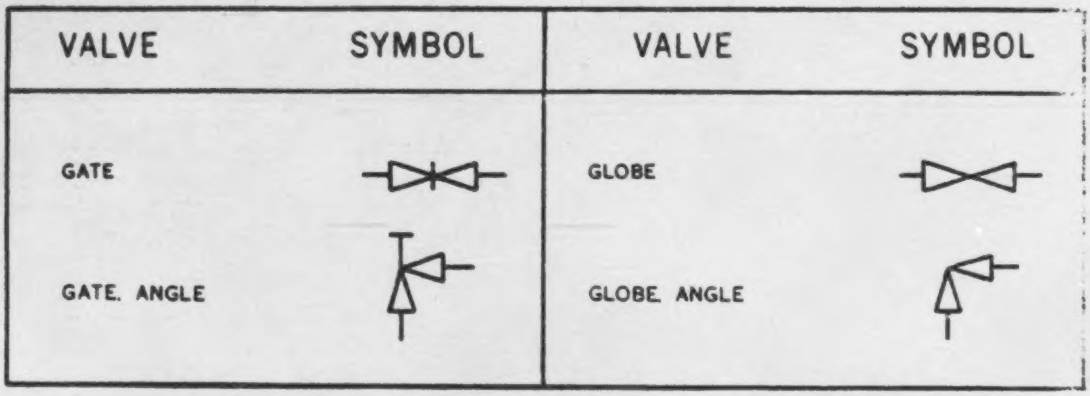

Figure 1-7. Symbols for valves.

When plumbing blueprints are not available, you will have to prepare a working drawing or sketch of the job. The symbols used on blueprints or drawings to indicate pipe runs are shown in figure 1-5. You must learn these symbols in order to be able to locate the water supply systems on a blueprint.

A large variety of fittings are required to assemble the pipes in a water supply system. A few of the symbols for pipe fittings are shown in figure 1-6.

Valves of different designs and types are also used in water supply systems. Some of them control the direction of flow of the water in the pipes, whereas others regulate the amount of flow to different parts of the system. Some of the symbols that are used to identify the different valves on blueprints are shown in figure 1-7.

Faucets are used to control the flow of water at the outlets in the system. Notice the symbols that are used on blueprints to indicate the types of faucets listed in figure 1-8.

The locations for fixtures are taken from the building blueprint and placed on the working drawing through the use of symbols. Further study of the blueprint will enable you to form a mental picture of the pipe required for both the cold and hot water supply systems. The exact routing of the pipe should be located on the working drawing, with symbols used to identify the systems and to show the location of the valves and fittings.

Notice the symbols shown in figure 1-9. These symbols are used to avoid confusion between pipe intersections and pipe crossovers.

The intersection or joining of two pipes is shown by drawing the line symbols so that there is actual contact between the lines. Crossovers, where there is no connection between the pipes, are indicated by a break in one of the line symbols at the point where the pipes cross.

*Water supply system requirements.* After the pipe runs and fittings are located on the working drawing, the size of the pipe to be used in each line must be determined and indicated on the drawing. When a plumbing blueprint is available for the job, it will contain this information. When there is no blueprint, you must determine the pipe sizes necessary to carry the flow.

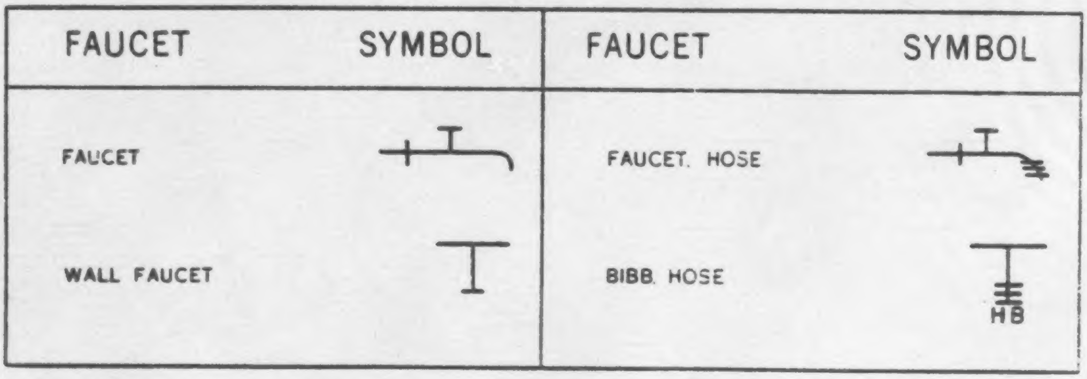

Figure 1-8. Symbols for faucets.

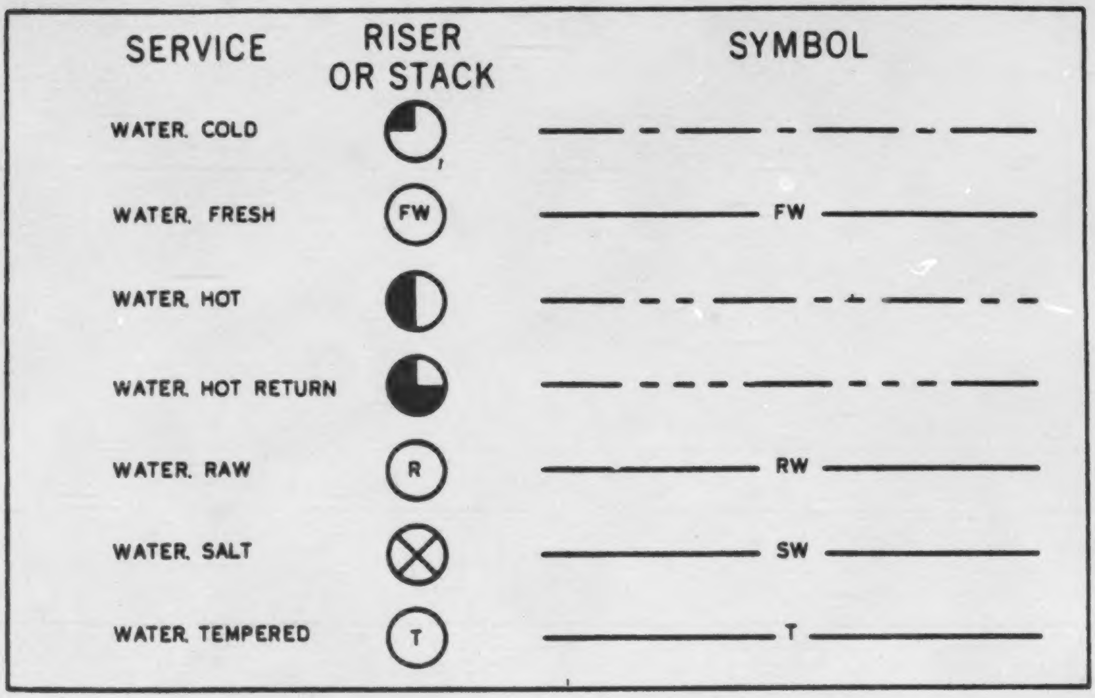
SERVICE
RISER OR STACK
SYMBOL
WATER. COLD
WATER. FRESH
FW
FW
WATER. HOT
WATER. HOT RETURN
WATER. RAW
R
RW
WATER. SALT
SW
WATER. TEMPERED
T
T

Figure 1-5. Symbols for pipe runs.

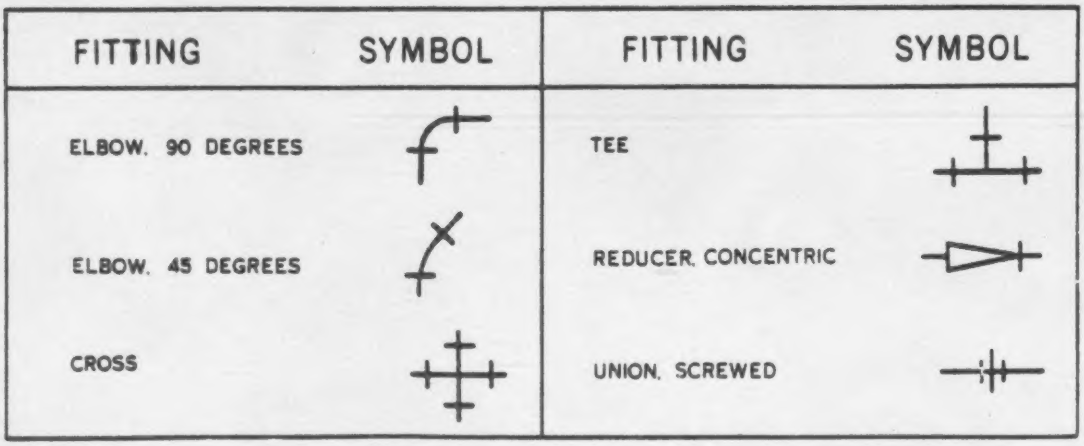
FITTING
SYMBOL
ELBOW. 90 DEGREES
ELBOW. 45 DEGREES
CROSS
FITTING
SYMBOL
TEE
REDUCER. CONCENTRIC
UNION. SCREWED

Figure 1-6. Symbols for screwed pipe fittings.

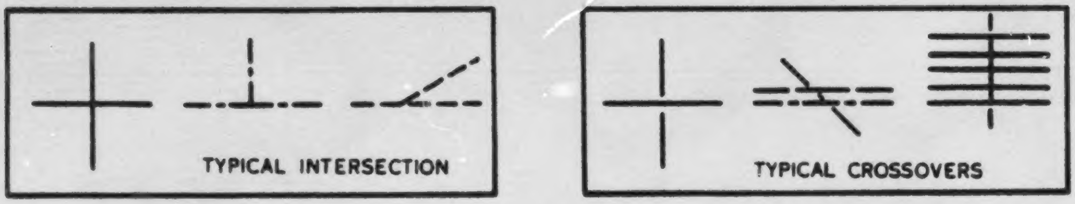

Figure 1-9. Typical pipe intersections and crossovers.

| TYPE OF FIXTURE | Units * | Gals. per minute |
|---|---|---|
| Urinal | 5 | 37 1/2 |
| Water closet, flushing valve | 6 | 45 |
| Lavatory | 1 | 7 1/2 |
| Shower | 2 | 15 |
| Sink | 2 | 15 |
| Laundry tub | 4 | 30 |
| Garden faucet | 2 | 15 |
| * 1 unit = 7 1/2 gals. | | |

Figure 1-10. Maximum fixture demand chart.

Some of the factors which affect the size of the water service in a plumbing installation are the types of flush devices used on fixtures, the pressure of the water supply in pounds per square inch, the length of the pipe in the building, the number and kind of fixtures installed, and the simultaneous use of the fixtures at any given time. The chart in figure 1-10 shows the water demand in gallons per minute for different fixtures. As an example, consider a plumbing system which consists of two urinals, one water closet, two lavatories, and two shower stalls. As you can see from the chart in figure 1-10, the two urinals, using 37½ gallons per minute (gpm) each, would use 75 gpm. The water closet would use 45 gpm. The two lavatories, using 7½ gallons per minute each, would use 15 gallons; and the two shower stalls would use a total of 30 gpm. The maximum fixture demand for this system is the total of these figures, which is 165 gallons of water per minute. Under ordinary circumstances, only a small percentage of the fixtures would be used simultaneously, and the probable demand for water must be estimated. As a rule for estimating the probable demand for small residences, you generally take about 30 percent of the maximum fixture demand in gallons. The chart shown in figure 1-10 is used to estimate the requirements for large plumbing installations.

| No. of fixtures | Percent of simultaneous use |
|---|---|
| 1 - 5 | 50 - 100 |
| 5 - 50 | 25 - 50 |
| 50 or more | 10 - 25 |

Figure 1-11. Factors of simultaneous use chart.

In the example above, there is a total of seven fixtures. As you can see in the chart shown in figure 1-11, this number falls between 5 and 50, so the factor of simultaneous use is 25 to 50 percent of the maximum fixture demand of 165 gallons, or approximately 82½ gallons. This figure represents the probable demand in gallons per minute for the system under normal usage. The size of the pipe used for the main water supply into the building can be determined by consulting the chart in figure 1-12. If the water pressure to the building is 60 pounds per square inch, then the building main should be constructed of 1½-inch pipe. The size for branch supply lines from the building main to the different fixtures may be determined by using the demand of an individual fixture in gpm and consulting the chart for the pipe size.

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| Pressure in pounds | Flow in gallons per minute * by size of pipe | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1/2 | 3/4 | 1 | 1 1/4 | 1 1/2 | 2 | 2 1/2 | 3 | 4 |
| 17 | 3.2 | 9.1 | 18.7 | 33.5 | 51.6 | 106 | 200 | 290 | 589 |
| 30 | 5 | 14 | 28 | 52 | 78 | 160 | 308 | 436 | 885 |
| 40 | 6 | 16 | 33 | 60 | 90 | 184 | 350 | 504 | 1023 |
| 50 | 6.5 | 17.5 | 37 | 70 | 101 | 206 | 390 | 564 | 1143 |
| 60 | 7 | 19.5 | 40 | 76 | 110 | 226 | 430 | 617 | 1252 |
| 75 | 7.5 | 22 | 45 | 85 | 123 | 253 | 480 | 690 | 1400 |
| 100 | 9 | 25 | 52 | 99 | 142 | 292 | 558 | 797 | 1607 |

* For 100 feet of pipe

Figure 1-12. Capacities of pipe sizes chart.

*Water supply system materials.* After the pipe runs and the sizes of the pipes are indicated on the working drawings, the proper sized fittings for connecting the pipes can easily be determined. The selection of valves for controlling the flow through the system presents a more complex problem. A well planned plumbing system has valves located throughout the system for controlling the flow. The risers or pipes that are concealed in the walls or floors should be equipped with shutoff valves for use in emergencies or while repairing the pipes. The gate valve, shown in figure 1-13, is used whenever a positive cutoff is desired. These valves are designed for use in systems where they are fully open or fully closed. Gate valves are never used to throttle the flow in a line. If they were used for throttling, the gate disc would chatter and soon wear until it would not stop the flow when seated.

The globe valve, shown in figure 1-14, is used in systems where the flow of water must be throttled. This valve has a horizontal interior partition which separates the inlet from the outlet except for an opening in the partition. A replacement fiber, rubber, or metal disc is attached to the lower end of the threaded valve stem; and the valve is closed by turning the handle until the disc seats over the hole in the partition.

**Exercises (401):**

1. What information is contained in a complete set of blueprints?

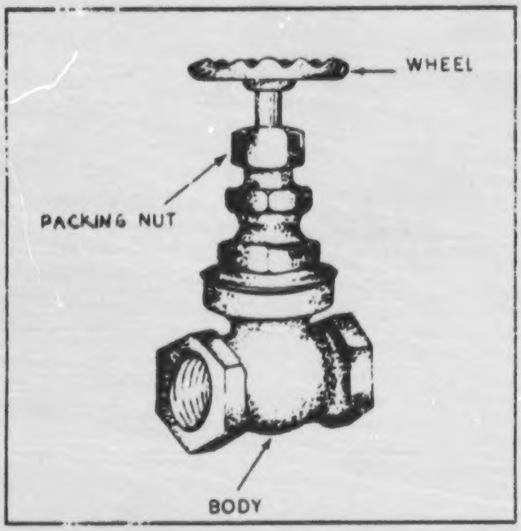


Figure 1-13. Gate valve

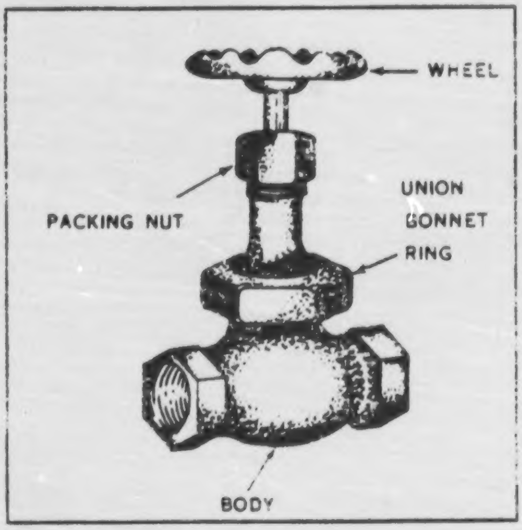


Figure 1-14. Globe valve.

2. **What substitute will you have to prepare when needed plumbing blueprints are not available?**

3. **What is used to control the flow of water at an outlet?**

4. **What is indicated on a working drawing by a break in one of the line symbols at the point where pipes cross?**

5. **What is the rule for estimating the probable water demand for small residences?**

6. **What should be incorporated into the installation of risers or pipes that are concealed in walls or floors to provide for emergencies or maintenance of the pipes?**

## 1-2. Installing a Water Supply System

The installation of a building water supply system includes tapping the water main and installing the corporation stop, curb stop, and meter stop. Most cities have a crew from the water department to tap the mains. However, as an Air Force plumber, you will be tapping water mains when you are installing building water supply lines. For this reason, it is important for you to know the proper methods for installing a water supply line and the procedure for operating the water main self-tapping machine.

**402. Provided a list of materials, identify the items that would be listed as takeoff items.**

**Preparing a Bill of Materials.** We have covered some of the materials that are used in a water supply system. Now let's prepare a bill of materials.

A complete bill of materials is usually made by the draftsman at the time he prepares the blueprints. When a bill of materials does not accompany the blueprint, one must be prepared by the plumber. A bill of materials is a tabulated list of requirements for a job showing the name, description, quantity, stock number, size, and sometimes the cost of the various items. A sample bill of materials is shown in figure 1-15. Quantities are taken from the plans or drawing by listing one item at a time, starting with the smallest size and progressing to the largest.

When a special type of valve or fitting is required for a particular job, the item should be located in a commercial manual, and the manufacturer's number and type should be shown on the bill of materials to insure positive identification.

A bill of materials in which the cost must be listed will require that each item be located in manufacturer's catalogs to obtain the unit cost.

A list of so-called takeoff items should also be included in the bill of materials. These are items that are known to be necessary to complete the job but which are not included on the prints or drawings. They

| ITEM | DESCRIPTION | PART NR | QUANTITY | SIZE | COST |
|---|---|---|---|---|---|
| 1 | Valve, Gate-Brass with Wedge Disc, 100 Pound Pressure | Crane 410 or Equal | 6 | 3/4" | 4. 10 each |
| 2 | Valve, Gate-Brass with Wedge Disc, 100 Pound Pressure | Crane 410 or Equal | 2 | 1 1/4" | 6. 60 each |
| 3 | Valve, Globe-Brass with Composition Disc 150 Pounds Water Pressure at 200°F | Crane 1250 or Equal | 3 | 3/4" | 3. 40 each |
| 4 | Coupling, Pipe Reducer, Galvanised, 125 Pound Pressure | FSN 4730-277-2774 | 12 | 3/4" x 1/2" | .11 each |

Figure 1-15. Typical bill of materials.

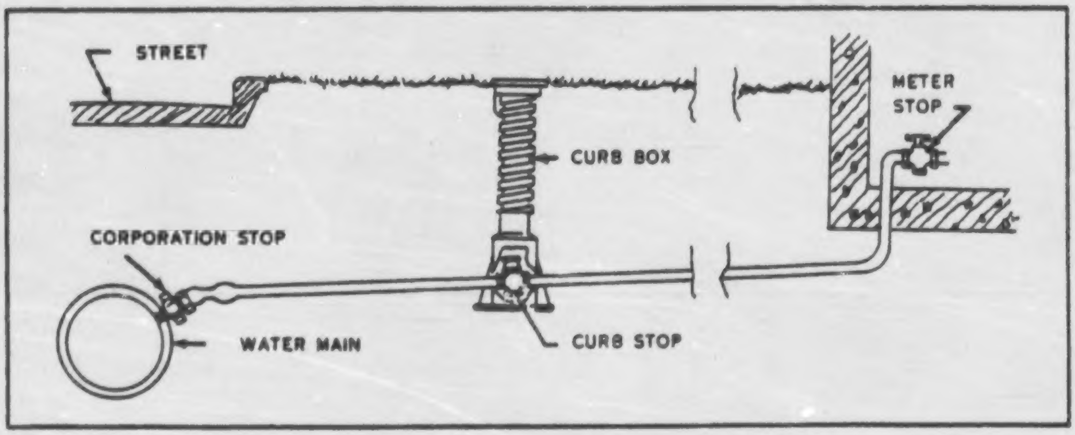


Figure 1-16. Typical building water supply system.

include such items as thread cutting oil, joint compounds, and bolts or screws for attaching brackets.

**Exercises (402):**

From the following list of materials, identify those items that are takeoff items by placing the letters TO in the spaces provided.

____ 1. Joint compound.
____ 2. Gate valve.
____ 3. Copper tee.
____ 4. Two-inch screws.
____ 5. 4'' center set.
____ 6. Cutting oil.
____ 7. Copper tubing.

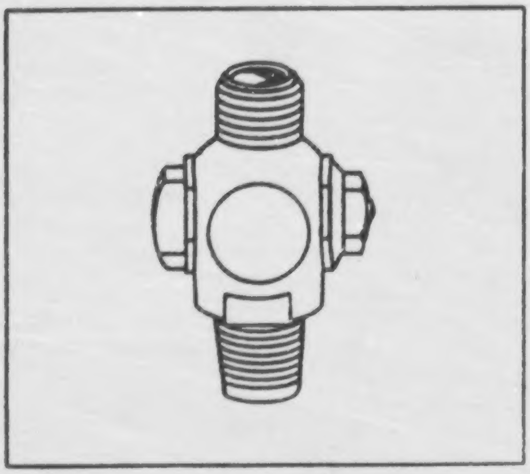


Figure. 1-17. Corporation stop.

**403. From a given list of statements, select those that pertain to the construction principles of a building water service line.**

**Construction Principles.** The building service or water service line is the line that is installed from the street water main to the building, as shown in figure 1-16. This line should run as directly as possible from the main to the building. The water service line usually has three controls or shutoffs. They are the corporation stop, curb stop, and meter shop.

*Corporation stop.* The corporation stop, shown in figure 1-17, is a valve which is installed in the street water main and which serves as a takeoff for the building water supply system. It is installed with an automatic tapping machine when the pressure is on in the main. The corporation stop cannot be used as a shutoff after it is installed because it is covered with soil.

*Curb stop.* After the water main has been tapped and the corporation stop installed, the next job is to locate and install the curb stop. The curb stop, shown in figure 1-18, is installed in an iron curb box at an accessible spot between the curb and the house, as shown in figure 1-16. The purpose of the curb stop is to provide an accessible shutoff for the water supply to the building from the outside.

*Meter stop.* After the curb stop has been installed, the supply line is run to the building and through the building wall to the inside of the basement. Now, the meter stop, shown in figure 1-19, is installed immediately within the wall of the building. The purpose of the meter stop is to control the flow of water to the system from inside the building. Some codes require that a gate valve be placed in the line immediately after the meter stop, because it is not built for frequent opening and closing. In this type of installation, the meter stop is closed only when the meter is removed or replaced.

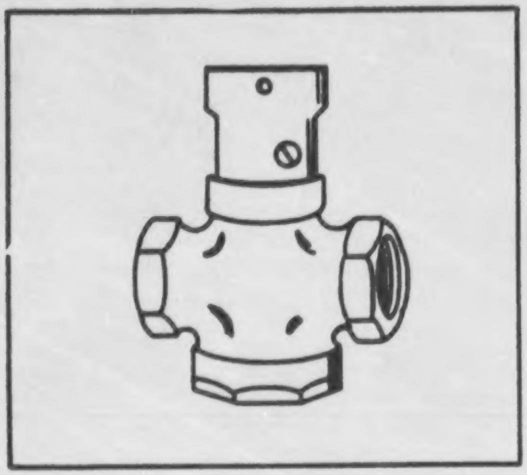


Figure 1-18. Curb stop.

Since the Air Force does not use water meters in buildings, the meter stop is not necessary. A gate valve is installed in its place for controlling the water flow into the building.

*Stop and waste valve.* In addition to the three valves mentioned above, a building supply line should be equipped with a stop and waste valve, shown in figure 1-20, which may be used for draining purposes. This valve must be located at a point in the grade that will drain the building pipes by gravity when the valve is turned to the off or drain position. The stop and waste valve is designed with a drilled passage through the side of the valve body that allows the water to escape. When the valve is turned to the off position, the water to the pressure or inlet side of the valve is shut off and the water on the outlet or building side of the valve is drained by gravity through the drilled passage in the valve body. The stop and waste valve can be installed either inside or outside the building. When the valve is installed inside the building, such as in a basement, it may be necessary to install a drain pipe from the drilled opening in the valve to carry the waste water to a floor drain or sump.

Materials that are generally used for the water supply line are copper, galvanized iron, plastic, or cast iron. Galvanized iron, plastic, or copper is commonly used for residences and small buildings, and cast iron is used for large buildings.

Some plumbing codes will not allow the water supply line to be laid in the same trench with the sewer line. Since digging two trenches is expensive, many codes allow lines to be laid in the same trench, but with certain precautions. The water supply line must be laid above the house sewer and on a shelf of undisturbed, solid soil. This prevents the water supply line from settling to a level with or below the sewer.

**Exercises (403):**

Select the statements that pertain to the construction principles of a building water service line by placing a checkmark (√) in the appropriate spaces.

____ 1. The corporation stop serves as a takeoff point at the street main for a building water supply system.

____ 2. Some codes require that a gate valve be placed in the line immediately after the meter stop.

____ 3. All Air Force buildings will have a meter stop.

____ 4. A building supply line should be equipped with a stop and waste valve.

____ 5. When the sewer and water lines are laid in the same trench, the water line must be laid on a shelf of undisturbed solid soil.

**404. Provided a list of statements concerning tapping the water main, distinguish between those that are true and those that are false.**

**Tapping the Water Mains.** After the trench has been dug to the main, a corporation stop can be installed while the main is under pressure by using the water main self-tapping machine illustrated in figure 1-21. A 1-inch tap is the largest opening that can be made while the main is under pressure. Ninety pounds is the maximum pressure that can be tapped against with a water-tapping machine. It is important that you understand the operation of the machine before attempting to tap a main under pressure. The tap should be located as near the top of the water main as possible. Clean the rust and dirt from the main at the point where the tap is to be made. Place the machine gasket on the main and mount the tapping machine

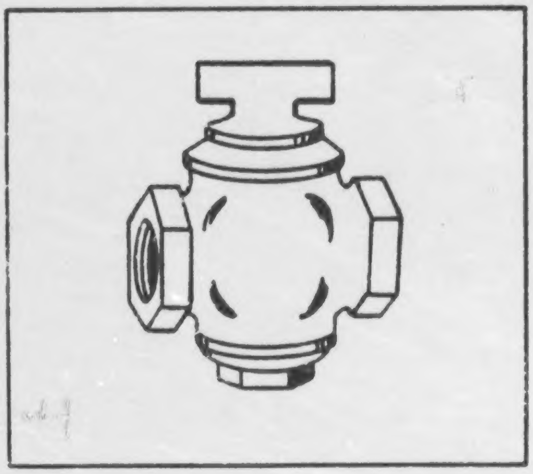


Figure 1-19. Meter stop.

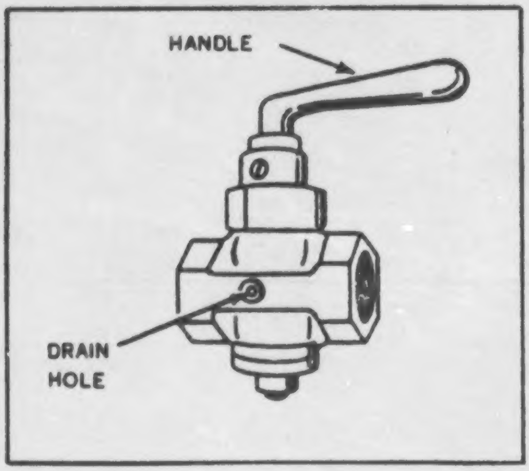


Figure 1-20. Stop and waste valve.

over the gasket by wrapping the tie chain around the main. Tighten the chain mounting bolts until a solid, watertight connection is formed between the main and the machine base. Check the depth adjustment on the boring bar and insert the proper sized drill and tap into the holder. Assemble the machine by inserting the boring bar through the cylinder and tightening the cap. Start drilling the hole by applying pressure at the feed yoke while operating the ratchet handle. After the drill penetrates the main, the boring bar will turn easily until the tap starts cutting threads. When the tap starts threading the hole, the feed yoke should be backed off to prevent the threads in the main from stripping. Continue to turn the boring bar until the depth adjustment hits the stop. This is indicated by a tightening of the ratchet handle until it can no longer be turned without undue force. To remove the tap from the hole, reverse the ratchet and back the boring bar out by turning it in a counterclockwise direction. When the boring bar is raised high enough to clear the bottom of the cylinder, close the flop valve. Check to see that the bypass valve is closed to prevent water from entering the cylinder. The water under pressure from the main will be trapped in the machine base, and you can remove the boring bar by unscrewing the machine cap. Remove the drill and tap tool and install a corporation stop of the proper size in the end of the boring bar. Be sure that you can screw the handle of the corporation stop into the main by turning the boring bar. Since you closed the corporation stop before installing it, the only noticeable water leak from the operation would be from the water that is trapped in the cylinder of the machine. Release the water pressure from the cylinder by opening the bypass valve and removing the boring bar. Disengage the chain from the main and remove the machine. Check for leakage around the corporation stop. If a leak is evident, tighten the stop with an adjustable jaw wrench.

**Exercises (404):**

Distinguish between the true and false statements, by placing a T or F as appropriate in the spaces provided.

____ 1. One inch is the largest opening that can be tapped while the water main is under pressure.

____ 2. The maximum pressure that can be tapped against is 80 pounds.

____ 3. When the tap starts threading the hole, the feed yoke should be backed off to prevent the threads in the main from stripping.

____ 4. The corporation stop should be in the closed position when installed.

**405. Match the appropriate flexible connector to the type of pipe with which it should be used.**

**Installation of Flexible Connectors.** When you install the line between the corporation stop and the curb stop, some type of flexible connection must be used for joining the pipe to the corporation stop. The purpose of the flexible connection is to protect the corporation stop from strain, damage which might

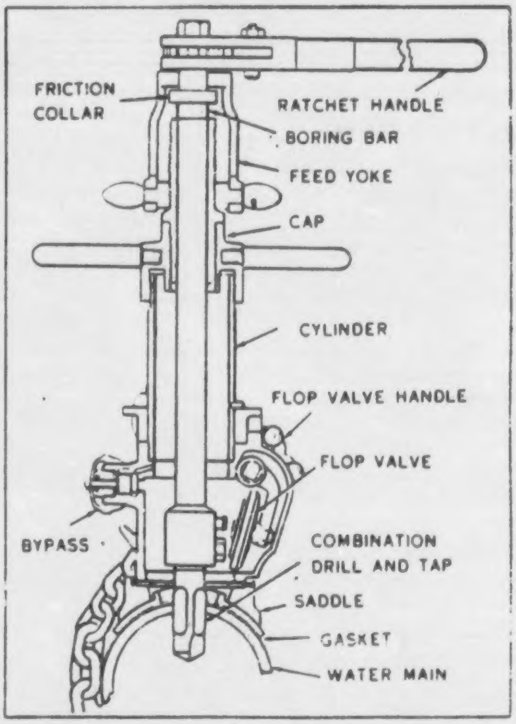


Figure 1-21. Water main self-tapping machine.

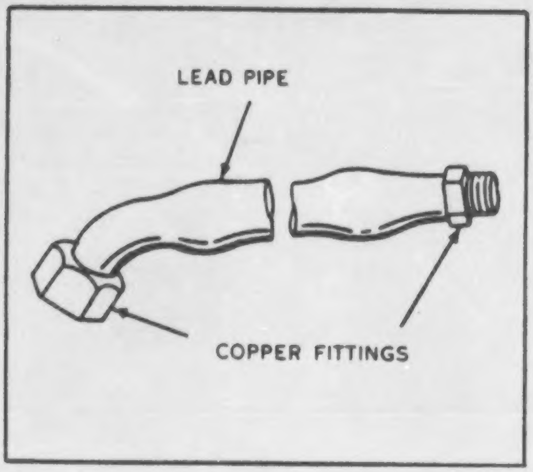


Figure 1-22. Flexible gooseneck connector.

result from any movement of the water main, service pipe settling, earth movement, expansion, or contraction.

*Copper or lead connectors.* Flexible connectors, sometimes called goosenecks, as illustrated in figure 1-22, are available for use when galvanized iron or steel pipe is used for the supply line. The connector consists of a length of lead or copper pipe which has fittings wiped or soldered on each end for connecting to the corporation stop and supply piping.

*Swing joint.* The swing joint is another type of flexible connection that is commonly used with a galvanized iron or steel service line. As you can see in figure 1-23, this connection consists of two elbows separated by a short section of pipe or nipple. Install one of the ells and the nipple onto the corporation. stop so that the nipple points in the same diruction as the water main. Install the second ell onto the nipple so that it points toward the curb stop, and install the supply line between this ell and the curb stop. The flexibility of the threaded joints at the two ells will protect the corporation stop from strain or damage in the event of any movement of the pipe after the trench is backfilled.

*Expansion loop.* When copper tubing is used to fabricate the water supply, an expansion loop, shown in figure 1-24, should be formed in the line near the connection to the corporation stop—this to be used instead of the copper or lead connectors or swing joints. Be careful to insure that no part of the expansion loop will be above the frostline after the trench is backfilled.

**Exercises (405):**

Match the connectors in column A with the pipe in column B by placing the appropriate letters in the spaces provided in column A. Letters may be used more than once.

| *Column A* | *Column B* |
|---|---|
| ___ 1. Expansion loop. | a. Iron or steel pipe. |
| ___ 2. Swing joint. | b. Copper tubing. |
| ___ 3. Gooseneck. | |

## 1-3. Temporary Water Mains

You may never have to install a temporary water main unless you happen to be in an area where a disaster occurs. Disasters such as earthquakes, bombings, or eruption of an old water main may create the need for temporary water mains.

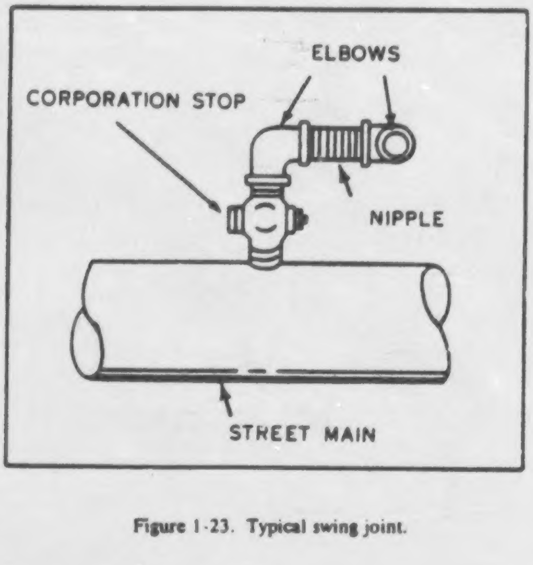


Figure 1-23. Typical swing joint.

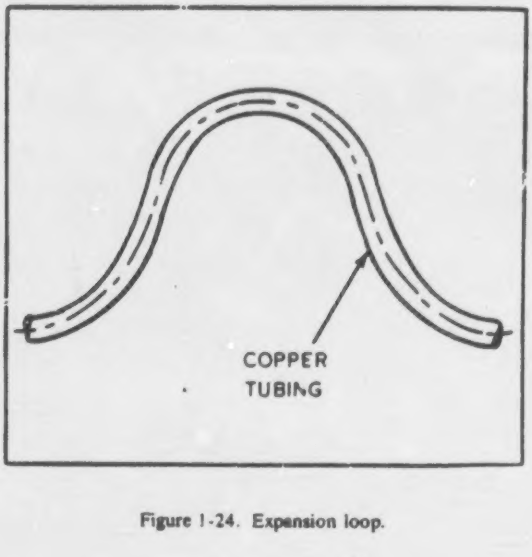


Figure 1-24. Expansion loop.

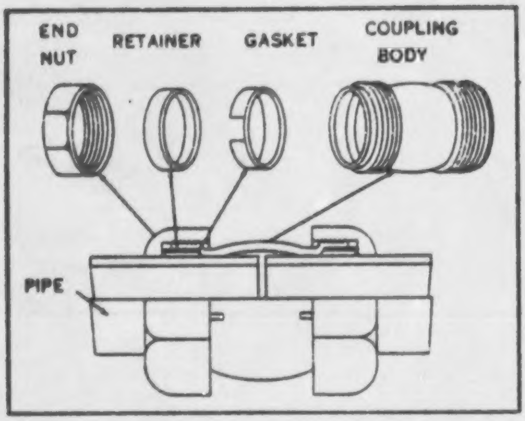


Figure 1-25. Compression coupling for small size pipe.

**406. From a list of materials, identify those that can be used in constructing a temporary water main.**

**Materials Used in Temporary Water Mains.** You have just learned how to install a typical water supply system; now let's find out about the materials used in temporary water mains.

Any materials available at the time may be used for constructing temporary water mains in an emergency. The size of the main will determine to some extent the type of pipe to be used. Galvanized iron pipe is normally used for lines up to 1½ and 2 inches in diameter. Cast-iron pipe may be used for constructing a 2-inch line. A mechanical type compression sleeve coupling can be used to assemble galvanized or cast-iron pipe sections in less time than would be required for conventional threaded joints. Figure 1-25 shows a compression coupling and illustrates the different parts of the coupling. Notice how the end nut compresses the gasket between the retainer and the pipe on one side and the coupling body on the other.

Water mains which are 3 inches in diameter or above may be constructed of either steel or asbestos pipe. A large main is more difficult to install because of the problems involved in handling the pipe and fittings. Asbestos pipe should be used when available because it weighs much less than comparable sizes of steel pipe.

Cement-asbestos pipe is manufactured by several companies. The outside diameters of pipes which have the same inside diameter but which are manufactured by a different company will vary because of a difference in wall thickness of the pipes. The manufacturer determines the wall thickness required for his pipe by the strength of his product. Therefore, because of such variations in the outside diameters of the pipes, it is advisable to use couplings and pipe from the same manufacturer in order to insure a proper fit.

A cutaway view of a coupling used with cement-asbestos pipe is shown in figure 1-26. The coupling consists of a sleeve, which may be made of metal but is usually made of asbestos, that has a groove machined near each end on the inside surface. Rubber sealing rings are fitted into grooves to seal and lock the joint when the tapered ends of the pipe are pressed into the sleeve. These joints can be made without specially skilled labor, and are flexible so that no expansion joints are required. Cement-asbestos pipe is used extensively for mains up to and including 24 inches because of these characteristics.

Another type of coupling that may be used on larger sizes of steel or asbestos pipe is the clamp or saddle

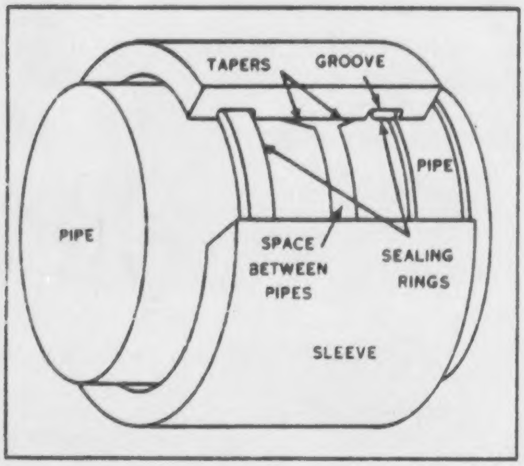


Figure 1-26. Asbestos-cement coupling.

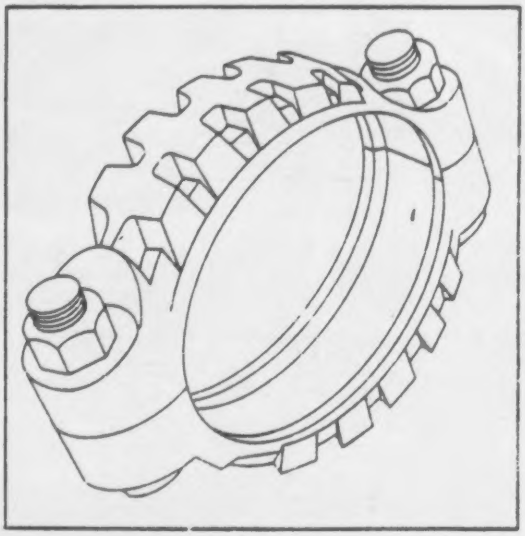


Figure 1-27. Saddle type pipe coupling.

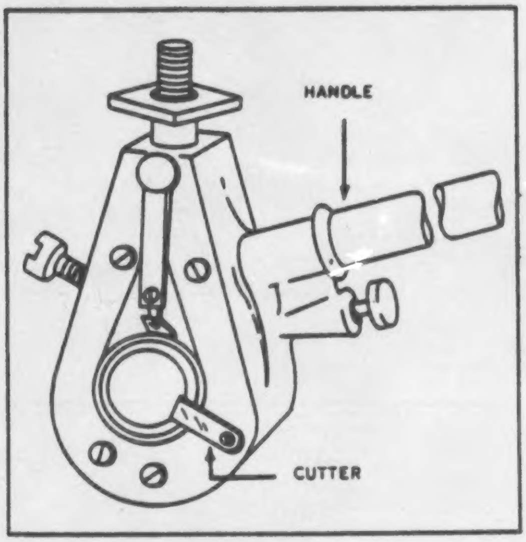


Figure 1-28. Pipe grooving tool.

type, shown in figure 1-27. This coupling is available in designs for use on plain end pipe or pipe which has grooved ends.

The grooving tool, shown in figure 1-28, is used to cut grooves in plain end pipes. Any pipe that has a sufficient wall thickness for threading can be grooved, because the depth of the groove is less than the depth of the thread.

The coupling is assembled by positioning a gasket over the pipe ends to be joined and then placing the clamp halves over the gaskets. The nuts on the bolts should be tightened until the clamp halves make contact with each other. No additional torque is required for tightening the bolts.

A selection of fittings which have grooved ends is available for use with grooved end pipes. The various valves and fittings needed to route and control the flow can be determined from the design and purpose of the temporary main.

**Exercises (406):**

Identify the materials that can be used to construct a temporary water main by placing the letters "TWM" in the appropriate spaces.

____ 1. Galvanized steel.
____ 2. Vitrified clay.
____ 3. Asbestos cement.
____ 4. Cast iron.
____ 5. Fiber.
____ 6. Steel.

**407. Provided a list of statements, select the true statements pertaining to assembling pipe and fittings.**

**Assembling Pipe and Fittings.** Now that you know about the materials that are used in temporary water mains, let's complete this water supply business by learning how to assemble the pipe and fittings that are used in a temporary water main.

Temporary water mains are usually installed on top of the ground unless they are exposed to freezing weather. Portions of the main may be buried underground at a street crossing or in areas where damage to the main might occur. Compression couplings are used on steel pipes when the temporary main must be installed in a hurry and when the main will be in use only a short period of time. Mains that

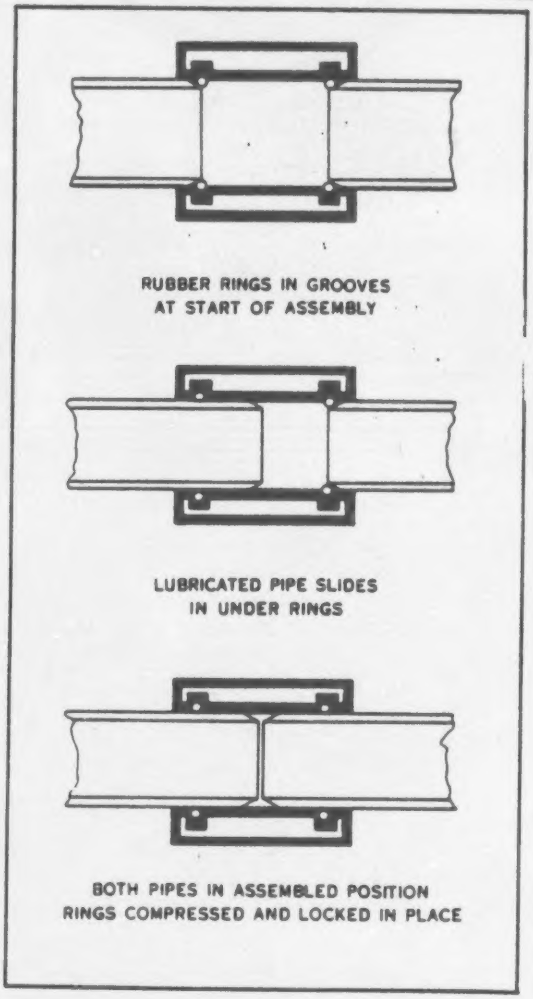


Figure 1-29. Assembly of an asbestos pipe joint.

must handle high water pressures must be secured at intervals along the run of the line, and at all turns when compression couplings are used. This prevents whipping of the pipe under pressure and separation at the couplings.

To assemble small diameter steel pipe with a compression coupling, like the one that was shown in figure 1-25, first place the end nut, second the retainer, and last, the gasket over the ends of the two pipes to be connected. Insert the pipe ends into the coupling body and be sure to leave a space between the pipe ends for expansion. Slip the gaskets along the pipe and position them against the flanged ends of the coupling body. The retainer protects the gasket from damage when the end nut is tightened.

Large sizes of compression couplings are assembled in much the same manner as the smaller couplings. The end rings usually have a depression between an inner and outer rim to hold the gasket in position. The gasket is placed in the ring; then the ring is placed over the end of the pipe. After the pipe ends are positioned in the center ring, the end rings and gaskets are moved into place against the center ring. The bolts are then installed and alined through two end rings. The nuts should be tightened progressively by working around the pipe. Do not overtighten any one nut, but work around the coupling and be sure to place an even tension on each bolt.

Steel pipes of random lengths and plain ends can be used with compression couplings. This saves much time during pipe assembly, because the pipe ends do not have to be threaded.

Line joints are made on cement-asbestos pipe by inserting the pipe ends into a rubber ring coupling as illustrated in figure 1-26. Considerable force is required to move the pipe ends into the couplings. An asbestos cement pipe jack with a chain and bar arrangement is used instead of wrenches to make the joints.

A lubricant is used on the pipe ends to reduce resistance as the pipe slips under the rubber sealing rings. The manner in which the pipe ends move into the coupling during assembly is shown in figure 1-29.

Changes in direction, up to 5°, can be made at each joint when laying curved portions of the line. Cement-asbestos pipe can be cut to any length by using a carpenter's handsaw, and it is also easily drilled and tapped for service connections. Each section must be tied or anchored when used above the ground, to prevent the joints from disengaging.

Bell type cast-iron water supply fittings and valves may be used with asbestos pipe. These joints can be made up similar to soil pipe joints by using sulphur base compounds or lead. A pneumatic caulking tool should be used when available for setting the lead to insure a positive and durable seal. Cast-iron drainage fittings should not be used in temporary water main construction, because they are not designed to withstand pressures.

Temporary water mains that are constructed for use while the existing system is being modified and when there is no emergency involved should be constructed of steel pipe whenever possible. Steel pipe and couplings are used because they can be disassembled and salvaged for reuse much more easily than asbestos pipe. Asbestos pipe couplings may have to be sawed apart when you take up the line.

**Exercises (407):**

Select the true statements by placing a T in the appropriate spaces.

____ 1. Temporary water mains are usually installed on top of the ground unless they are exposed to freezing weather.

____ 2. Pressure mains do not have to be secured.

____ 3. When installing compression couplings, the nuts should be tightened all the way on one side at a time.

____ 4. A jack with a chain and bar arrangement is used to make asbestos-cement pipe joints.

## 1-4. Sweat Soldering

Copper tubing and pipe have become increasingly popular due to the ease with which they can be assembled and installed, their life expectancy, and their resistance to corrosion.

### 408. Identify the different types of copper tubing.

**Types of Copper Tubing.** There are four types of copper tubing. They are K, L, M, and DWV. The classification of copper tubing is determined by its wall thickness.

*Type K copper tubing.* A green color band and/or a stencil on the tubing surface identifies the pipe as type K. It is recommended for underground installation and high-pressure systems. It is ideal for building service lines and compressed air systems. Type K is available in a variety of sizes ranging from 1/4 inch to 12 inches in diameter and has the thickest wall of the four types of tubing. Type K copper can be purchased in standard lengths of 20 feet for hard drawn, or coils of 25 feet to 100 feet annealed (soft drawn).

*Type L copper tubing.* A blue color band and/or a stencil on the surface of the tubing identifies its type. It has a medium wall thickness and is recommended for interior use in plumbing and heating installations. Type L is also available in 1/4 inch to 12 inches in diameter. Type L copper can also be purchased in standard lengths of 20 feet hard drawn, or coils 25 to 100 feet annealed.

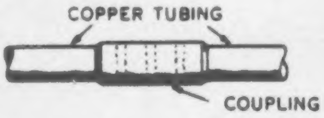
*Type M copper tubing.* Type M has a light wall thickness and is used in low-pressure installations. It is identified with a red color or stencil on its surface. Type M is available in sizes 1/4 inch to 6 inches in diameter.

*Type DWV copper pipe.* The DWV has the thinnest wall of all types of copper tubing. Drain, waste, and vent (DVW) is used only in above ground installations. It is furnished in hard temper only and is available in sizes ranging from 1¼ inches to 8 inches in diameter. It is available in standard lengths of 20 feet.

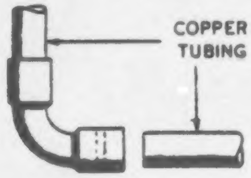
**Exercises (408):**

Identify the types of copper tubing by placing the appropriate letter(s) in the spaces provided.

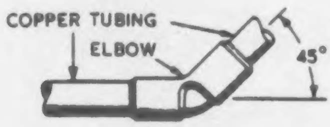
1. Type ______ has a light wall thickness and is used in low-pressure systems.
2. Type ______ has the thinnest wall of all copper tubing.


COPPER TUBING
COUPLING

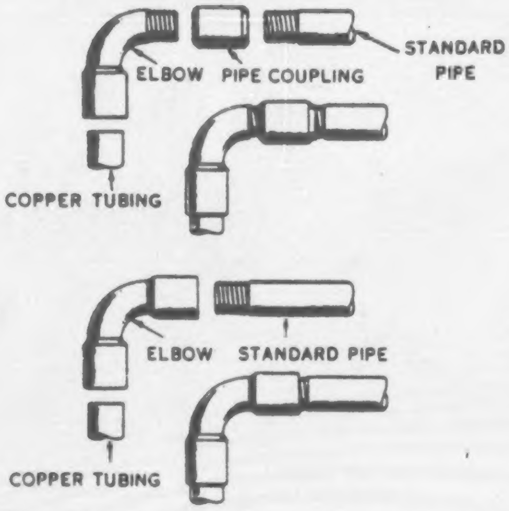
COUPLING (copper-to-copper)


COPPER TUBING

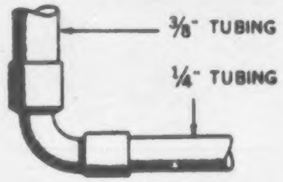
90° ELBOW (copper-to-copper)


COPPER TUBING
ELBOW
45°

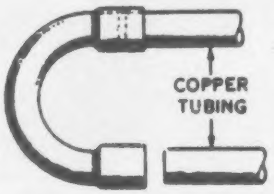
45° ELBOW (copper-to-copper)


ELBOW
PIPE COUPLING
STANDARD PIPE
COPPER TUBING
ELBOW
STANDARD PIPE
COPPER TUBING

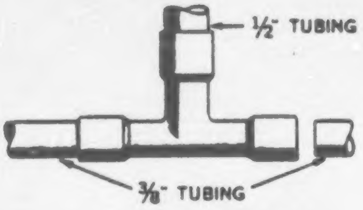
90° ELBOWS (copper-to-standard pipe)


⅜" TUBING
¼" TUBING

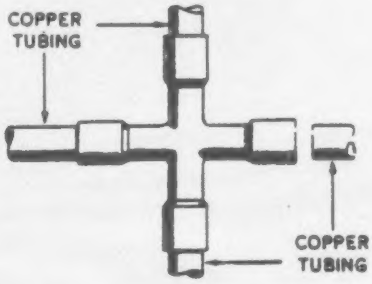
90° ELBOW (copper-to-copper reduction)


COPPER TUBING

RETURN BEND (copper-to-copper)


½" TUBING
⅜" TUBING

TEE (copper-to-copper)


COPPER TUBING
COPPER TUBING

CROSS (copper-to-copper)

Figure 1-30. Typical sweat type fittings.

3. Type ______ has a medium wall thickness and is recommended for interior use in plumbing and heating.
4. Type ______ is recommended for underground use and high-pressure systems.

**409. Provided a list of statements related to joining copper tubing, differentiate between the true and false statements.**

**Joining Copper Tubing.** Now that you know the types of copper tubing that are used in water supply systems, let's find out how this tubing is joined together in order to carry water supplies into buildings.

Copper tubing may be joined by any of three methods: by using compression type fittings, by flaring the tubing and using flaring type fittings, or by sweat soldering the joints. Sweat soldering is the only method discussed in this chapter. The other methods are covered in a later chapter.

Sweat soldering is a method of joining two metals together by allowing molten solder to run between the tube and fitting. The law of capillary attraction governs the force responsible for bonding in solder joints. The tube and fitting must be cleaned thoroughly to remove oxidation, and then fluxed to prevent further oxidation during the soldering operation. Heat is applied to melt the solder as it is applied to the joint. Capillary attraction then draws the solder between the tube and fitting for the full depth of the fitting. This forms a neat, leakproof bond that is stronger than the tube itself.

*Types of fittings.* There are many types of fittings available for use with copper pipe and tubing. Nearly all sizes are stocked by most plumbing dealers. These fittings include valves, cocks, adapters, and the general run of fittings like those shown in figure 1-30. Sweat fittings may be used with copper pipe for water supplies and drainage and waste systems. Adapters are used to make connections between copper pipe, galvanized pipe, or cast iron.

*Cutting copper tubing.* Prepare copper tubing for use by first determining the measurements necessary for the particular installation. When you have determined the length, cut the tubing with a tube cutter or a hacksaw.

The tube cutter for copper is similar to the pipe cutter for iron pipe, except that it is smaller. To cut tubing with a cutter, mark the tubing where it is to be cut and install the cutter on the tube so that the cutter wheel is over the mark. Then turn the tube cutter adjustment clockwise to force the cutter wheel against the tubing. Revolve the cutter around the tubing. Continue revolving the cutter, turning the knob slightly after each revolution, until the tubing is cut through and separates..

Copper tubing may also be cut with a hacksaw if a tube cutter is not available. Select a hacksaw blade with fine teeth to do the cutting. Be sure you cut the tubing square. Use a miter box to insure a square cut.

After the tubing has been cut with a tube cutter, you must remove the burr inside the tube. Do this with a tube reamer. Place the point of the reamer into the end of the tubing, and turn the reamer alternately in opposite directions until the burr is removed. Do not use tubing that has not been reamed, because the burr will restrict the flow of liquids and gases through the pipe.

*Cleaning copper tubing.* When you prepare joints for soft soldering, be thorough. Make sure that the metal surfaces are perfectly clean at the joint to obtain a good bond between the base metal and the solder. Remove all dirt, grease, oil, paint, etc., and brighten the metal. Clean the tubing with a wire brush, file, emery cloth, or steel wool. You may use chemical cleaners also. The parts to be joined should fit together very closely, because the only thing that should be necessary to make the joint is a thin film of freely flowing solder.

*Soldering equipment.* A high-temperature concentrated flame that will quickly bring the fitting to the melting point of solder is the only heat that is necessary for "sweating" fittings on copper tubing. Fifty-fifty solder (50 percent lead and 50 percent tin) melts at 360° F. and is freeflowing at 415° F. Silver solder, which is used for high-pressure lines, has a much higher melting point and is free flowing at over 1000° F. Figure 1-31 illustrates a propane torch that is ideal for sweat soldering small copper lines. When soldering large lines, if it is at all possible, use an air-acetylene torch, like the one illustrated in figure 1-32. This type of torch consists of a small portable cylinder of acetylene gas, a regulator, hose, and torch. The air-

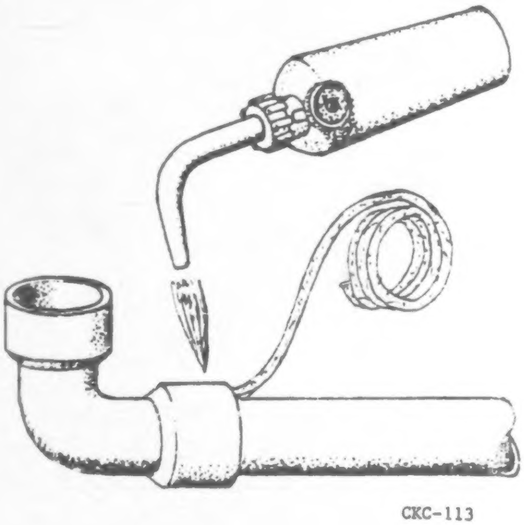


Figure 1-31. Propane torch.

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acetylene torch is very efficient and produces a good flame for soldering. The acetylene gas mixes with the atmosphere to support combustion and produces a flame up to 4000° F.

*Sweat soldering joints.* When the fitting and tubing are ready to be joined, apply heat evenly around the fitting. Do this by moving the flame back and forth. This procedure prevents the tube and fitting from overheating. If you overheat the connection, the flux may burn out, causing oxidation, and the solder will not spread evenly. An overheated joint causes the solder to seep through the joint and flow away. For this reason, test the heat occasionally by touching the fitting with solder where the tubing and fitting join. Normally, thick wall fittings require more heat than thin wall fittings. When the tube and fitting melt the solder, begin the sweating procedure.

As soon as the connection reaches the correct temperature to melt the solder, remove the flame and apply the solder to the edge of the fitting where it comes in contact with the tube. Solder, when confined between two surfaces, will run uphill by capillary attraction. Therefore joints can be made in any position. The amount of solder required for a connection depends upon the diameter of the tube to be sweated. For instance, 1/4 inch of solder should be sufficient to solder a joint for 1/4-inch tubing, 1/2 inch of solder for 1/2-inch tubing, etc. (The amounts suggested are based on solder with a diameter of 1/8 inch.) When a line of solder shows up around the fitting, that is, a head of solder appears in the groove at the end of the fitting, the joint has all the solder it will take. When you apply solder to a tee, feed solder from both ends of the fitting. Reheat the fitting slightly to help the solder penetrate into the metal. Remove the flame and continue to feed the solder to make sure the joint is filled.

Allow the joint to cool for a short while. A rag or wad of waste saturated with water will hasten the cooling. Allow more time for the solder to set when you cool male and female adapters, because these fittings are heavier, hold the heat longer, and do not cool as quickly.

When unsoldering a tube from a fitting on which other soldered connections are to be left intact, you must be careful not to melt the solder in the other connections. Keep the connections that are to be left intact cool by applying wet cloths to them. You may also use wet cloths to protect valves and other units from the intense heat. Make a shield from a sheet of asbestos paper and slip it over the tubing to protect combustible materials or a flammable wall while you are soldering.

**Exercises (409):**

Differentiate between the true and false statements by placing a T or an F as appropriate in the spaces provided.

____ 1. Copper tubing may be joined by three methods.
____ 2. Fifty-fifty solder is free flowing at 375° F.
____ 3. Silver solder is free flowing at 1000° F.
____ 4. Overheating a joint causes the solder to seep through the joint and flow away.
____ 5. A 1/2-inch solder joint requires 1/2-inch of solder if the solder is 1/8 inch in diameter.
____ 6. A piece of felt paper should be used to protect combustible materials when soldering.

## 1-5. Maintenance of Water Supply Systems

Breaks in water mains must be repaired as rapidly as possible to prevent unnecessary loss of water and to keep out-of-service periods in the affected areas to a minimum.

**410. Provided a list of repair clamps and situations pertaining to water main breaks, match the correct**

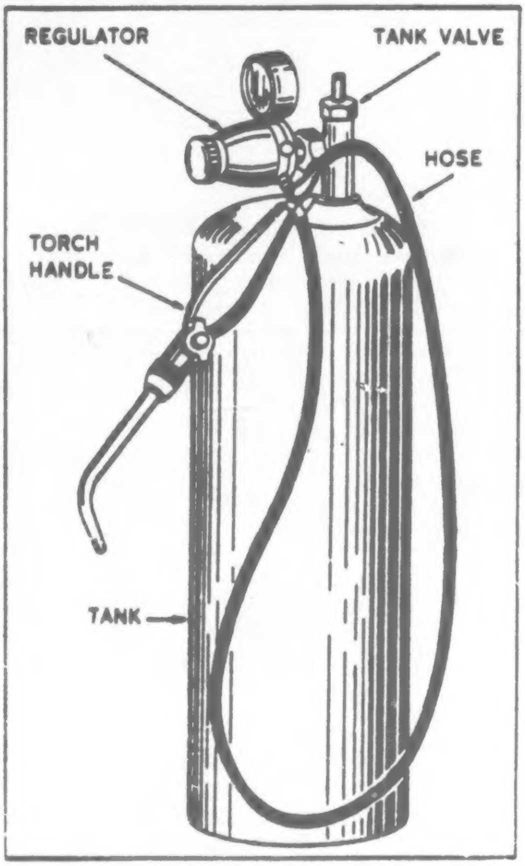

Figure 1-32. Air-acetylene torch.

**repair method to each water main break; also supply other required information concerning breaks.**

**Repairing Water Mains.** When you receive a call informing you that a water main is ruptured, speed in repairing the line is an important factor. You should be familiar with the water distribution maps so that you can turn off the water as quickly as possible. Materials to repair water mains should be kept on hand at all times, and should be readily accessible to repair crews.

One important item to remember is that while the water is off an area on the air base is vulnerable to fire for the lack of water. Any time a water main has to be turned off, the fire department must be notified. Fire department personnel need to know the exact section that is out of service so that they can make alternate plans in the event of a fire.

*Types of repair clamps.* An air base can have several types of piping, such as cast iron, asbestos cement, reinforced concrete, steel, and plastic. Figure 1-33 illustrates some of the types of breaks that you may find in mains and the methods of repairing them. When installing repair clamps, you should always remember to alternate from side to side while tightening the nuts. This will insure an even seal on the pipe.

*Draining excavations.* While excavating to repair water main leaks, it may be necessary to keep water pumped from the hole. This can be accomplished by using either a centrifugal or diaphragm type pump. The centrifugal pump works well when there is only water to be removed, but if there is mud or the possibility of rocks, you should use a diaphragm pump.

CAUTION: Always have an approved construction permit before doing any excavating.

**Exercise (410):**

Refer to figure 1-33 and match the correct repair clamp in column A to the water main breaks in column B by placing the correct letter in the spaces provided.

| *Column A* | *Column B* |
|---|---|
| 1. a. Split repair clamp. | ____ 1. Used to repair bell-and-spigot joint leaks. |
| b. Collar clamps. | ____ 2. Used to repair pit holes and small splits. |
| c. Band and saddle clamps. | ____ 3. Used to repair longitudinal splits. |
| d. Adjustable bell-joint clamp. | ____ 4. Used to repair leaks on threads of collars. |

2. Who should be notified any time a water main is turned off?

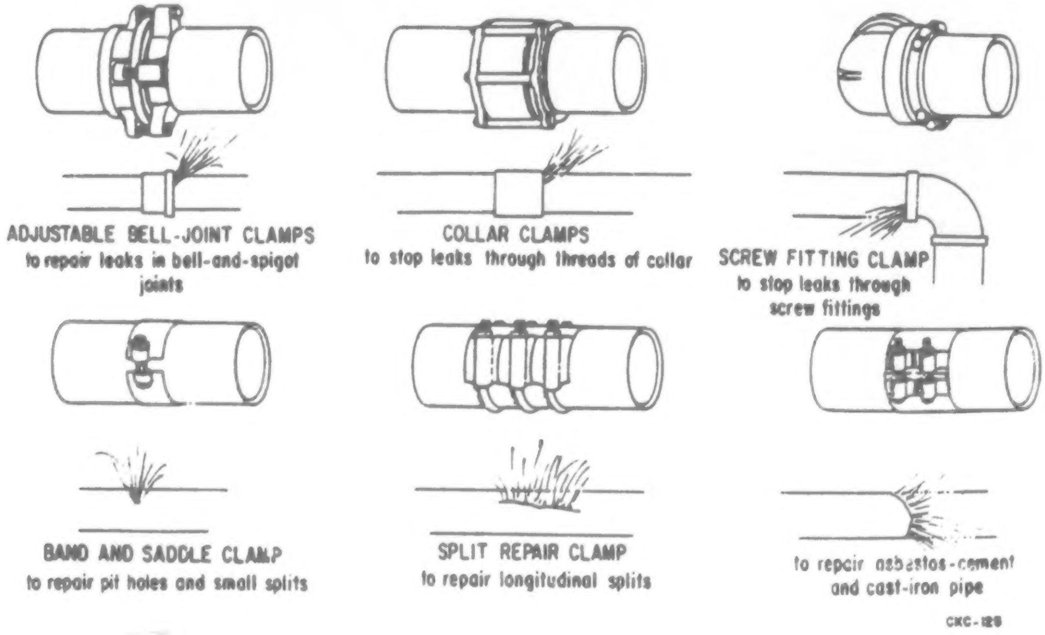
ADJUSTABLE BELL-JOINT CLAMPS
to repair leaks in bell-and-spigot joints
COLLAR CLAMPS
to stop leaks through threads of collar
SCREW FITTING CLAMP
to stop leaks through screw fittings
BAND AND SADDLE CLAMP
to repair pit holes and small splits
SPLIT REPAIR CLAMP
to repair longitudinal splits
to repair asbestos-cement and cast-iron pipe
CKC-128

Figure 1-33. Water main repair clamps.

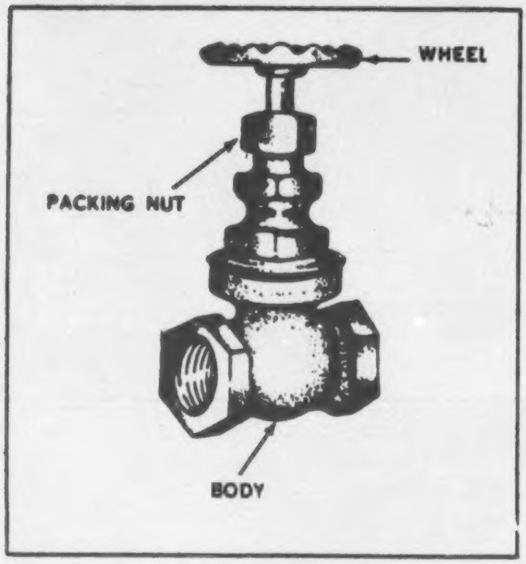

Figure 1-34. Gate valve.

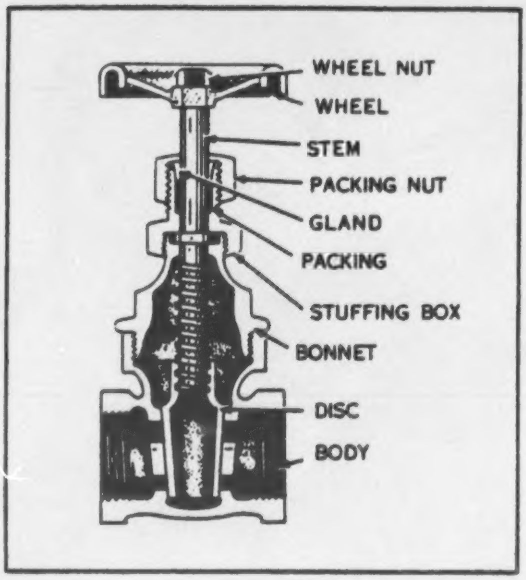

Figure 1-35. Nonrising stem gate valve.

3. What type pump should be used to pump a trench that has mud and rocks in the water?

**411. Distinguish between the true and false statements concerning maintenance of valves.**

**Maintenance of Valves.** You have just completed the section on the maintenance of waste systems. Next, we will learn how to maintain the valves in a plumbing system.

The use of valves to control the flow of liquids and gases into, through, and out of plumbing systems makes the knowledge of valve repair a necessity. In order to repair valves, you must be familiar with their construction and operation. You must also be able to inspect valves in order to determine what repairs are needed. Inspection of any valve consists of a close examination for visible wear and breakage.

*Gate valves.* A gate valve is one of the most used valves in a plumbing system. This valve is used either to shut off or regulate air or liquid systems. A diagram of a gate valve is shown in figure 1-34. Gate valves are designed in many different types, but they all work on the same principle. The two most commonly used gate valves are illustrated in figure 1-35 and 1-36. As you can see in the illustrations, the valve in figure 1-35 is one with a nonrising stem, whereas the valve in figure 1-36 is designed with a rising stem.

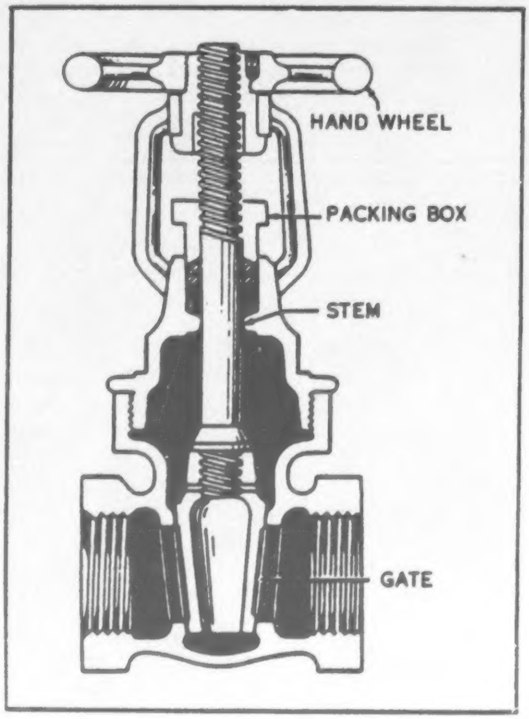

Figure 1-36. Rising stem gate valve.

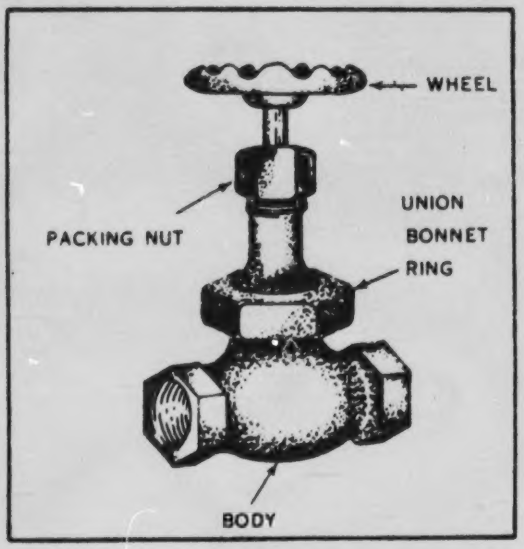

Figure 1-37. Typical globe valve.

A gate valve contains a sliding disc which moves vertically and seats between and against two seats to shut off the flow. A threaded stem is used to lift or lower the disc to open or close the valve. The volume of flow through the valve, however, is not in direct relation to the number of turns of the handwheel. Gate valves have either a single solid wedge-shaped disc or double disc with a wedge-shaped spreader to make a tight closure.

Gate valves are used for services where the valve is kept either fully opened or fully closed. However, to prevent binding, this type, after opening fully, should be turned back 1/4 to 1/2 turn from the fully opened position. Also back it off slightly from the fully closed position.

Gate valve leaks may occur at the valve seat, around the stuffing box, and at the body-bonnet joint. Repairs should be made at the first sign of a leak. Tightening a leaking joint usually corrects the condition. Other remedies are the replacement of gaskets or renewable parts, repacking stuffing boxes, or regrinding valve seats.

A stuffing box is part of a valve which holds the packing that seals the bonnet against leaks around the stem. Pressure is applied on the packing by a packing nut or gland flange which bears on a gland in the stuffing box. Packing wears in direct relation to its service. It loses life with age, but wear is mainly due to the rising and turning motion of the valve stem. Generally, the packing will last a long time and will need very little attention. Stuffing box leaks can usually be stopped by tightening the packing nut or gland of the valve. The bolted glands must be tightened evenly, because cocking will bind the stem. If a stuffing box leak cannot be remedied by tightening the packing nut, the packing must be replaced.

Inability to close a valve tightly is an indication of a valve seat leak. This type of trouble is usually caused by scale, metal particles, or other foreign matter in the line. Occasionally, valve leaks develop from a cut in the seat or disc caused by a high velocity flow of fluid through a limited area when the valve is not fully closed. When a valve leaks, the seat and disc may be repaired if the damage is not too extensive. If the disc is made of soft metal, it may be refaced (lapped). Use a mixture of oil and lapping compound on a machined surface as an abrasive to reface the disc. Use a figure-eight motion to lap the two surfaces true to each other. Remove and replace gate valve seat rings either with a power lathe or by hand with a diamond point chisel. Coat replacement rings with a lubricant before installing them, and lap them after they have been installed.

*Globe valves.* The globe valve is another valve that is widely used in plumbing systems. This valve is shown in figure 1-37. The cross sections of two of the most commonly used globe valves are shown in figures 1-38 and 1-39.

A globe valve has a horizontal interior partition which shuts off the inlet from the outlet, except through an opening in the partition. The lower end of the valve stem holds a replaceable fiber or metal disc shaped and fitted to close the hole in the horizontal partition. The valve is closed by turning the handwheel clockwise until the disc presses firmly on the opening. The volume of flow through globe valves is roughly proportional to the number of turns of the handwheel. Globe valves may have either rising or nonrising

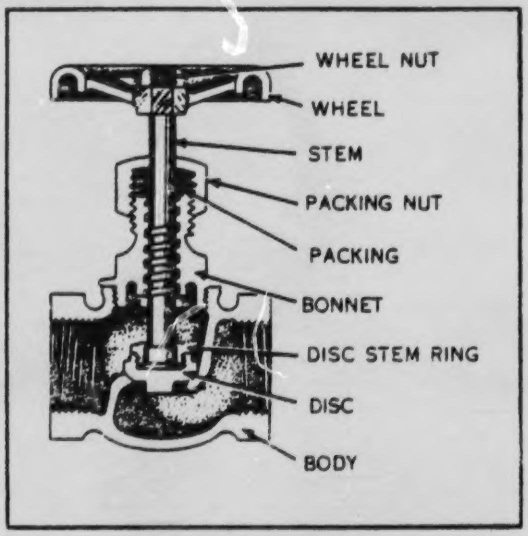

Figure 1-38. Globe valve with a conventional disc.

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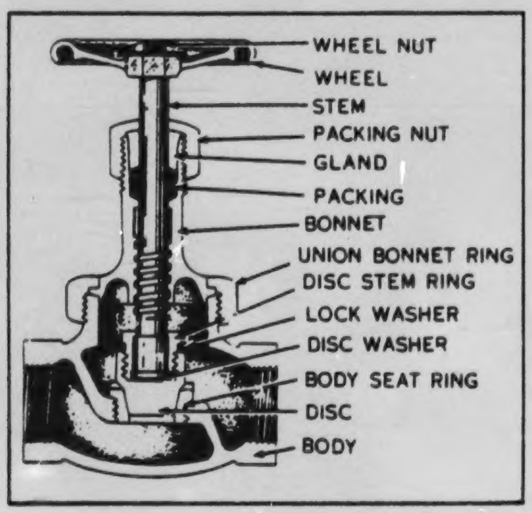


Figure 1-39. Globe valve with a plug disc.

stems. The surfaces of the seat and disc may be either flat or beveled, depending upon the type of disc.

A plug type disc consists of a tapered plug which provides a wide area of seating contact. This type of valve seating provides a very effective means of flow control and offers a high resistance to the cutting effects of dirt, scale, and other foreign matter.

A conventional disc, which forms a relatively narrow contact with the valve seat, provides a more positive and higher pressure contact than a wide seat. The thin line contact breaks down hard deposits that form on valve seats and insures a pressuretight closure. The conventional disc is made in several seating styles, such as flat seating, ball seating, and seating surfaces with varying degrees of taper.

A composition disc operates on the principle of a cap. Its face seats against or into the valve opening. Most composition discs consist of three parts: a metal disc holder, the disc itself, and a retainer nut. The primary advantage of a composition disc is the variety of disc materials available for individual services such as air, hot or cold water, gas, oil, gasoline, and other applications.

Globe valve leaks occur at the same points that they do on gate valves. When you find a leak in a globe valve with a plug type or conventional disc, repair the valve by removing the disc, inserting a washer under it, and then lapping the disc to the seat to make a snug fit. Correct a leak in a globe valve with a composition disc by replacing the disc. If the seat is severely pitted, replace the entire valve. Correct stuffing box leaks in the same manner as for gate valves. If tightening the packing nut does not stop the leak, replace the packing.

*Check valves.* Check valves, one of which is shown in figure 1-40, are used when it is necessary to control the flow of gases or fluids in one direction only. The flow in the proper direction keeps the valves open, and reversal of flow closes them automatically. There are two basic types of check valves: swing check valves and lift check valves. Both types have several variations that make them suitable for specific plumbing installations. They are used on hot water tanks to prevent hot water from backing up in the cold water lines, or anywhere on a plumbing system where free flow is needed in one direction only. Check valves are marked with an arrow which indicates the inlet opening or direction of flow for installation purposes.

*a.* Swing check valve. A swing check valve, of which a cross section is shown in figure 1-41, contains a hinged disc which seats against a machined seat in the tilted bridge wall opening of the valve body. The disc swings freely on its hinge pin in an arc from a fully closed position to one parallel with the flow. The fluid or gas in the pipeline enters below the disc. Live pressure overcomes the weight of the disc and raises it to allow a continuous flow. If the flow is reversed, pressure is exerted against the disc, forcing it to close and stop the flow.

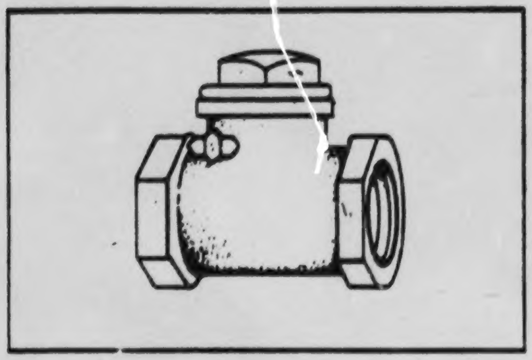


Figure 1-40. Check valve.

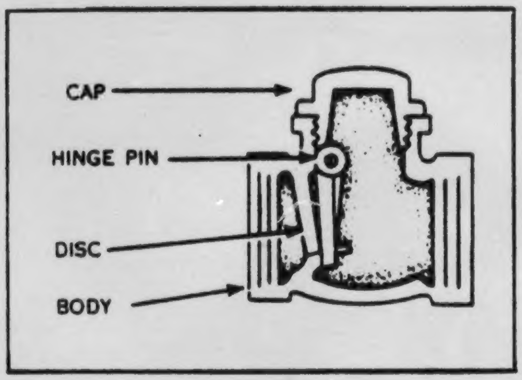


Figure 1-41. Cross section of a check valve.

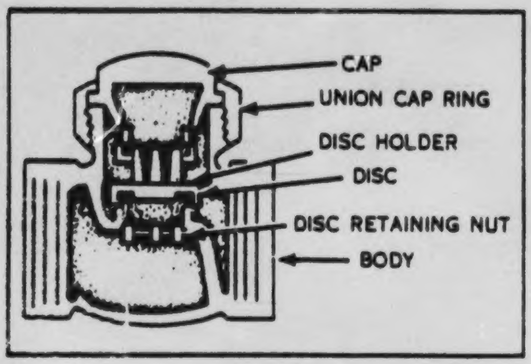


Figure 1-42. Cross section of a lift check valve.

During maintenance, inspect the operation of the swing check valve to determine if the hinge operates properly and the closure is tight. Replace the hinge or hinge pin when necessary. Tighten the hinge disc bolt if it is loose. Check the condition of the disc face and disc seat. If they are pitted, make the necessary replacements. Valve seats may be reground with a reseating tool or by lapping.

*b.* Lift check valve. A lift check valve, of which a cross section is shown in figure 1-42, contains a disc which seats on a horizontal bridge wall in the valve body. The disc moves up to open and is raised from its seat by the pressure of the fluid flow. To insure proper seating and rising, the disc is provided with short guides, which are usually above and below the disc. The valve is closed by backflow, or by gravity when there is no flow.

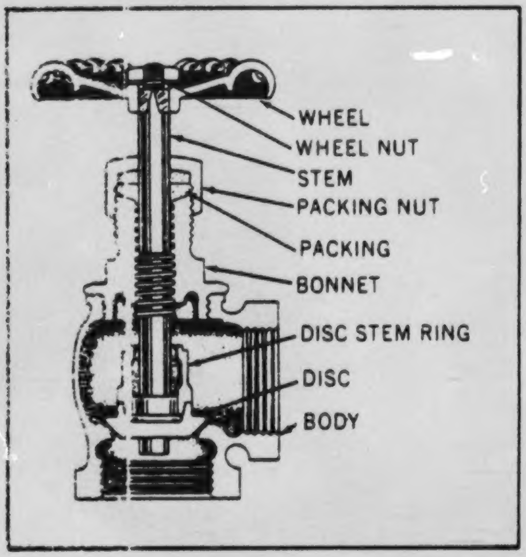


Figure 1-43. Cross section of an angle valve.

When there is evidence that a lift check valve is not working properly, inspect the operation of the lift disc. If it sticks, it should be freed. Clean the lift disc of all foreign matter such as dirt and corrosion. Check the condition of the lift disc and seat. If they are pitted, make the necessary replacements or regrind and reseat the units as required.

*Angle valves.* Angle valves are similar in construction and operation to globe valves, except that the valve outlet is at an angle of 90° to the inlet, as shown in figure 1-43. Angle valves should be maintained in a manner similar to globe valves.

*Plug valves.* Plug valves have a circular, tapered ground plug fitting which fits into a tapered hole or seat, as shown in figure 1-44. An opening through the plug permits the passage of fluid through the valve when the opening is alined with the pipeline. Plug valves may be completely and quickly opened by a one-quarter turn of the handle, and do not have soft packing, which tends to wear.

Leaks in plug valves can usually be corrected by cleaning or by adding a special lubricant to the plug. The lubricant makes it easier to turn the valve and also seals the points where the plug does not seat perfectly. If the valve seat is severely pitted, the entire valve must be replaced.

*Closet tank valves.* A water closet tank requires two valves. One is a float-controlled valve through which water enters the tank; the other is a flush-ball valve through which water is discharged from the tank into the water closet.

*a.* Water closet float-controlled valve. The water closet float-controlled valve, shown in figure 1-45, controls the flow of water into the flush tank. The

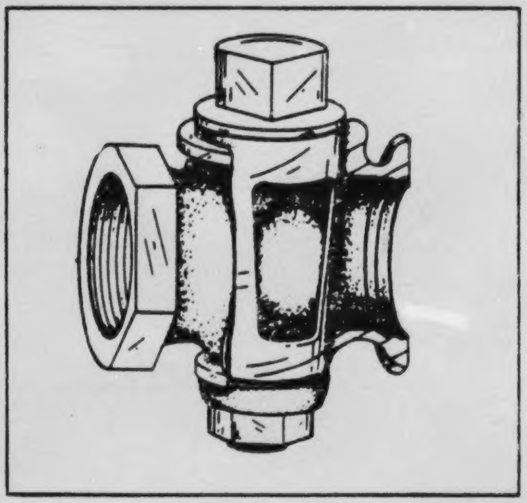


Figure 1-44. Cross section of a plug valve.

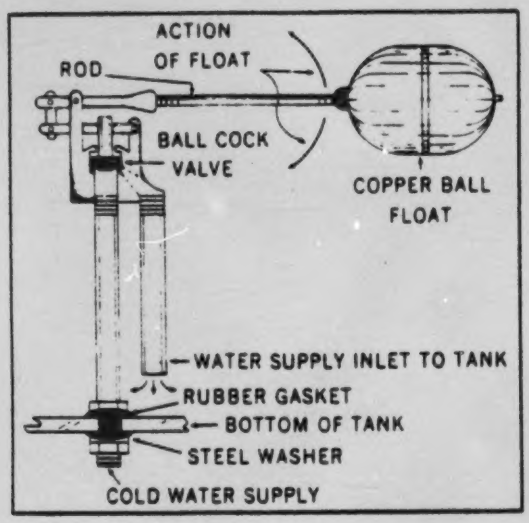


Figure 1-45. Water closet float-controlled valve.

quantity of water in the tank, when filled, is determined by the adjustment of the float when the valve is closed. When the water is emptied from the tank, the float drops, opening the float valve which admits water into the tank. A refill tube is provided to allow a small amount of water to enter the water closet bowl through the overflow pipe to fill the trap in the closet bowl while the tank is filling. When the float reaches its original position, the float valve closes and the tank is ready for the next flush.

The float-controlled valve is made of copper and brass and has a machined plunger as its principal component. The plunger is attached to two washers. One is a split, leather washer which encircles the plunger and insures a watertight seal of the machined surfaces. The other is a solid washer inserted into the bottom of the plunger. The seat of this washer moves down and closes off the flow of water to the closet tank. These two washers are the primary cause of all trouble with the float valve, and should be replaced at the first sign of wear. If sand is present in a water system, it will lodge in the float valve and prevent the washers from seating properly. This usually occurs after repairs have been made to a water main. The valve mechanism must operate freely and must not be worn excessively. Check the ball-float to see that it is not punctured.

*b.* Water closet flush-ball valve. The water closet flush-ball valve, shown in figure 1-46, is used in a closet tank to release water from the closet tank into the closet for flushing. This valve is usually operated by a trip lever which lifts the ball off the valve seat. The ball is buoyant, and when lifted, floats until the water level recedes to a point where the ball is drawn onto the valve seat by suction. The ball is held on the valve seat by the water pressure above it.

A flush-ball valve consists of a machined seat, flush ball, and an overflow tube. The machined seat is not subject to wear, because the ball which closes the opening in the seat is softer than the seat. The flush ball is a small rubber or plastic ball which is open on the bottom. It seats into and closes the flush-ball valve, except during the flushing cycle, and is connected to the operating handle by a trip lever and a system of rods. The flush ball becomes worn by constant reseating of the flush-ball valve, and becomes soft, rotten, or deformed through normal operation. Replace faulty flush balls, because they cause leakage of water into the water closet. This condition produces noise and wastes water. Be sure the rods holding the flush ball are kept clean and properly alined or the ball will not slide back into position. Replace the rods if they seem to be worn or affected by corrosion.

*Flushometer valves.* There are several types of flushometer valves that are used with water closets, urinals, and similar fixtures. The piston and diaphragm types are the most commonly used flushometer valves.

*a.* Piston type flushometer valve. The piston type flushometer valve, of which a cross section is shown in figure 1-47, is opened by a lever which discharges the

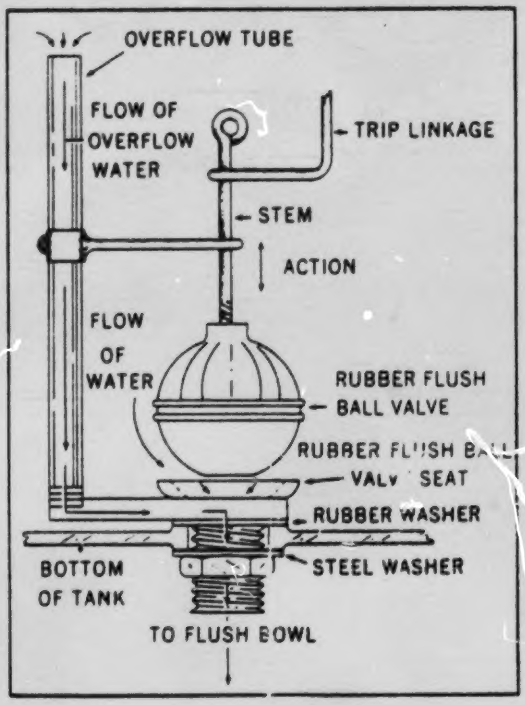


Figure 1-46. Water closet flush-ball valve.

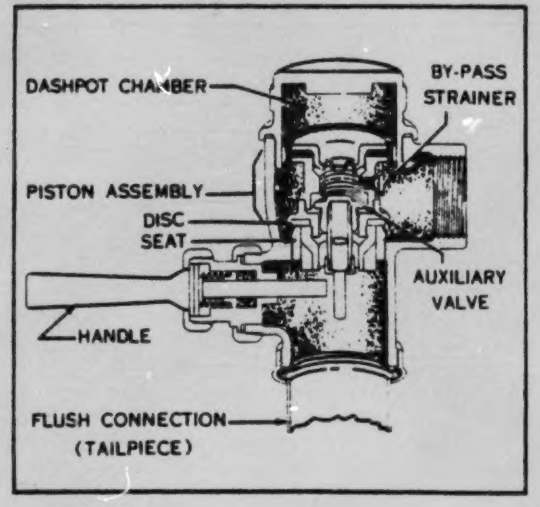

DASHPOT CHAMBER
BY-PASS STRAINER
PISTON ASSEMBLY
DISC
SEAT
AUXILIARY VALVE
HANDLE
FLUSH CONNECTION (TAILPIECE)

Figure 1-47. Cross section of a piston type flushometer valve.

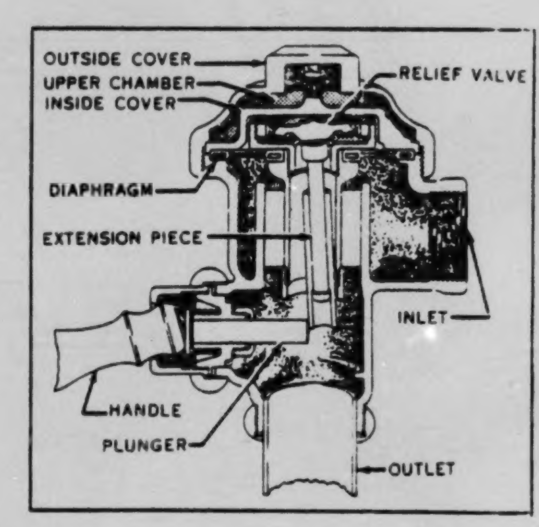

OUTSIDE COVER
UPPER CHAMBER
INSIDE COVER
RELIEF VALVE
DIAPHRAGM
EXTENSION PIECE
INLET
HANDLE
PLUNGER
OUTLET

Figure 1-48. Cross section of a diaphragm type flushometer valve

water from the dashpot chamber. The reduced water pressure in the dashpot chamber then forces the piston assembly by upward and allows the water to enter the closet directly. The closing of the valve is automatically controlled by a bypass through which water enters the dashpot chamber, forcing the piston assembly down on its seat and stopping the flow of water. The valve closing is regulated by a screw which allows the valve to be opened no longer than the time required to flush the bowl.

The maintenance of the piston type flushometer valve requires cleanliness. Repair kits are available for this type of valve. The kits include a bypass strainer, disc and seat, and other minor units. Be sure you know what type and model of valve you are reconditioning so that you will procure the proper kit.

*b.* Diaphragm type flushometer valve. The diaphragm type flushometer valve, shown in figure 1-48, contains two chambers separated by a relief valve mounted on a rubber diaphragm. The upper chamber is directly connected to the main water supply by a bypass. The lower chamber is connected to a large diameter supply pipe, which is usually 1 inch or more in diameter. When the valve is operated, the relief valve is tilted to an open position, thus discharging the water from the dashpot chamber. The inequity of pressure then forces the diaphragm to lift and admit water from the distribution system into the water closet. Within a predetermined interval, a sufficient amount of water forces itself through the bypass to the

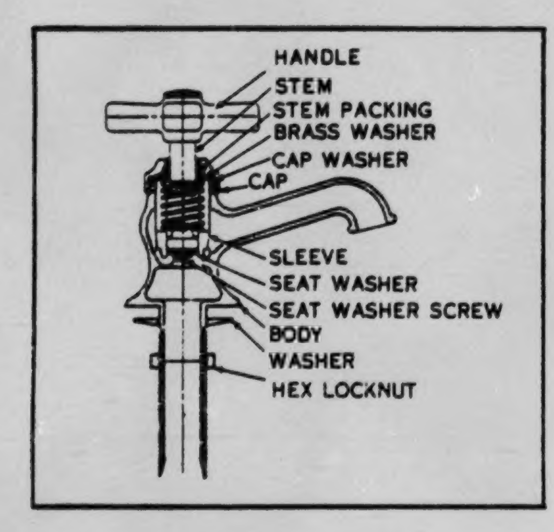

HANDLE
STEM
STEM PACKING
BRASS WASHER
CAP WASHER
CAP
SLEEVE
SEAT WASHER
SEAT WASHER SCREW
BODY
WASHER
HEX LOCKNUT

Figure 1-49. Cross section of a typical compression faucet.

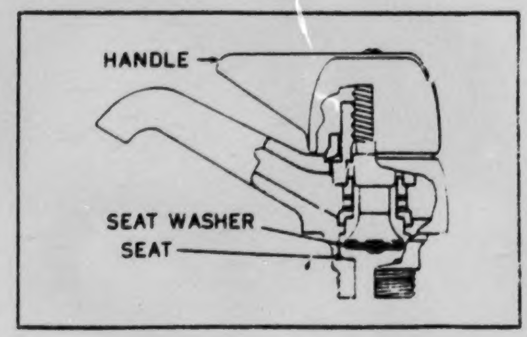

HANDLE
SEAT WASHER
SEAT

Figure 1-50. Cross section of a typical lavatory faucet.

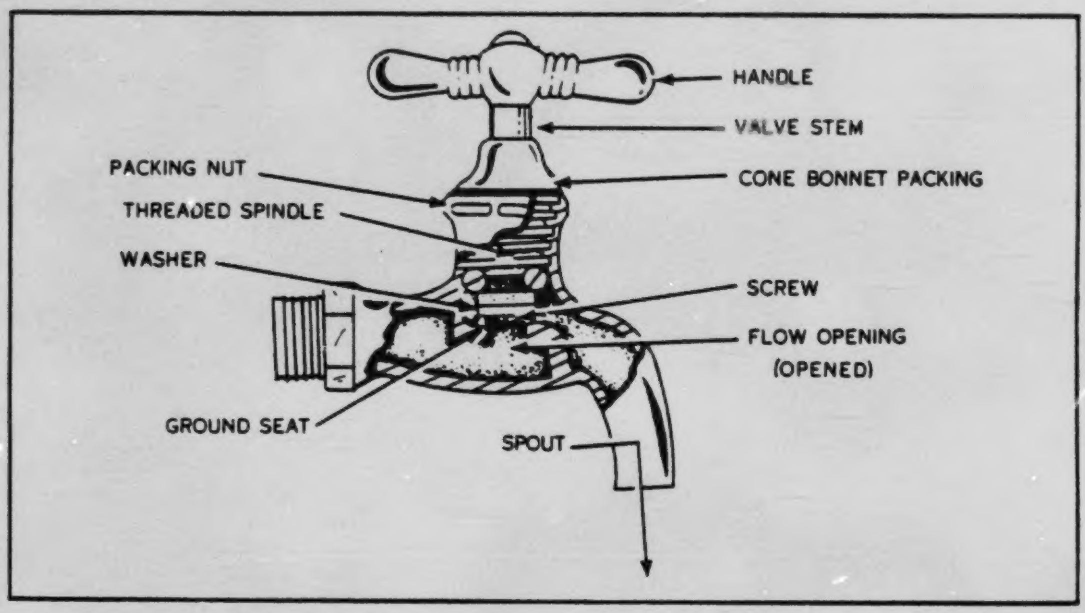


Figure 1-51. Cross section of a combination compression faucet.

dashpot champer, forcing the diaphragm down on its seat to stop the flow of water into the fixture.

The correct operation of a diaphragm valve depends upon its cleanliness. Dirt or scale in the water may cause it to leak or become inoperative. Repair kits are also available for this valve as they are for the piston type valve. These kits include the diaphragm and other minor units. Be sure you get the proper repair kit for the particular valve you are repairing.

*Compression faucets.* A compression faucet is one in which the flow of water is controlled by a washer which is compressed against a seat by turning a threaded spindle to which the washer is attached. There are two types of compression faucets. In one type, the body of the faucet is threaded to receive a correspondingly threaded stem that carries the washer to the seat; in the second type, the threaded stem actuates a square plug which moves vertically inside a body squared to match the plug. The faucets, shown in figures 1-49, 1-50, and 1-51, are typical compression faucets.

Leaks are the major maintenance problems of faucets and are usually caused by insufficient packing around the faucet stem or by improper seating of the washer on the valve seat. Continual leaking of water after a faucet has been closed tightly by hand usually indicates a worn washer. To repair the faucet, remove the screw in the center of the washer at the end of the stem and remove and replace the washer. Be sure you use the proper type of washer, because washers for hot water service are usually made of a different material from washers for cold water service. If the surface of the faucet seat which the washer compresses against is rough or damaged, the seat must be repaired with a reseating kit or the complete faucet must be removed and replaced.

*Mixing valves.* Mixing valves are units that are used to mix cold and hot water to a desired temperature. This method of mixing the water is called tempering the water. The types of mixing valves are the manually controlled, pressure controlled, and thermostatically controlled units.

*a.* Manually controlled mixing valve. The manually

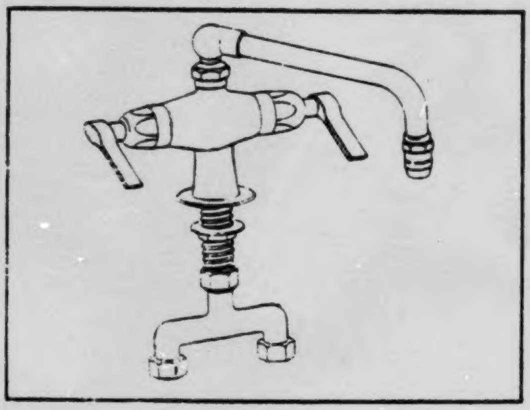


Figure 1-52. Manually controlled mixing faucet.

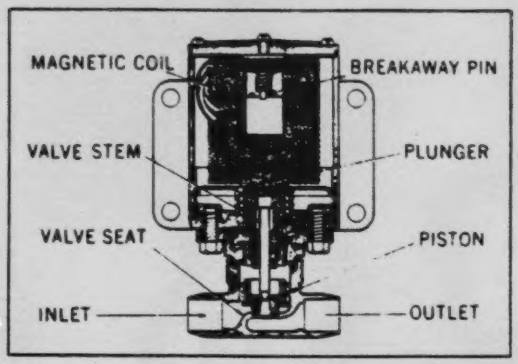


Figure 1-53. Solenoid valve.

controlled mixing valve, shown in figure 1-52, consists of two compression stops cast in one body, and in some cases a spray delivery pipe. It is similar in construction to a compression faucet.

The mixture and temperature of the water are regulated manually. This valve is repaired in the same manner as compression faucets.

*b.* Pressure controlled mixing valve. The pressure controlled mixing valve consists of a brass mixing chamber which contains a sliding piston. The piston is provided with jets to allow hot and cold water to pass through them and mix when the handle of the valve is operated. The setting of the handle controls the water temperature by establishing the mixing ratio. A change in pressure on one side of the piston will cause the piston to move and increase the flow from the low-pressure supply to maintain a nearly constant temperature. If cleaning and adjusting the sliding piston does not make this type of valve operate properly, it must be removed and replaced.

*c.* Thermostatically controlled mixing valve. The thermostatically controlled mixing valve is sensitive to changes in both temperature and pressure. The temperature of the water remains constant, regardless of the temperature and pressure changes in the hot and cold water lines. Special tools are needed to repair this type of valve. The thermostatically controlled mixing valve should be removed and replaced when it does not function properly.

*Automatic valves.* Automatic valves are devices that control the flow of liquids and gases automatically. Some are electrically operated, whereas others are operated by air pressure. A few of the most important automatic valves are discussed in the following paragraphs.

*a.* Solenoid valve. Notice the components of the solenoid operated valve, illustrated in figure 1-53. This valve is installed in a pipeline to control the flow of fluid or gas. The construction of the valve is similar to that of a globe valve, but it is operated by electricity. When the magnetic coil is energized by an electrical current, the plunger is drawn up into the coil and at the same time lifts the piston off its seat. This allows the fluid or gas to pass through the valve body of the valve. When the current is shut off, a spring or gravity action returns the piston to its seat and shuts off the valve.

The solenoid valve usually gives adequate service with very little maintenance. If the valve fails to operate, check for loose electrical connections or the lack of electrical power. Keep the valve mechanism clean and free of foreign matter. Recondition the valve seat and piston if necessary.

*b.* Motorized valve. The motorized valve is also used to control the flow of gases and liquids in a plumbing system. This valve is designed with a reversible electrical motor and a set of reduction gears The motor and gears operate an arm or eccentric which opens or closes a valve when electrical power is applied to the motor.

Motorized valves should be kept clean, and the electrical motor should be covered to protect it from dust and dirt. The motor and gears should be oiled as required. The valve and valve seat should be reconditioned when they become pitted.

*c.* Pneumatic valve. The pneumatic valve, shown in figure 1-54, is used to control the flow of liquids and gases in the system. The body of the pneumatic valve is similar to that of the globe valve, but the valve disc is operated by a spring and diaphragm. The pneumatic valve is so designed that a spring holds the valve disc on its seat, but the application of air pressure to the diaphragm raises the valve off its seat. Thus, the valve can be remotely operated by air pressure. Vacuum-

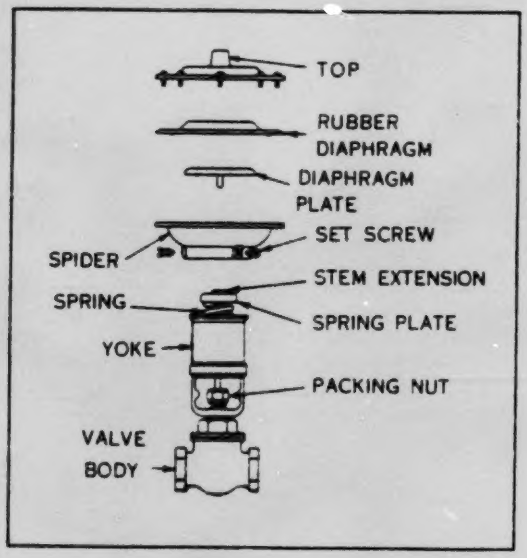


Figure 1-54. Exploded view of a pneumatic valve.

operated valves are constructed the same way, but the diaphragm is operated by vacuum.

Pneumatic valves usually give trouble-free service for long periods of time. However, the internal components must be kept free of foreign matter. Inoperative valves may be caused from leaky diaphragms, lack of air pressure, pitted valve discs and seats, broken return springs, and corroded valve stems.

*d.* Pressure-reducing valve. The pressure-reducing valve, shown in figure 1-55, maintains a desired air pressure regardless of the pressure from the source of supply. The pressure spring holds the spring down off its seat when the air pressure is low. An air pressure above the desired amount will force the diaphragm up. This action allows the piston spring to reseat the piston and stop the flow of air until the pressure drops.

The regulator usually gives trouble-free service for a considerable length of time. In some cases, the diaphragm develops cracks because of continual flexing. If the valve seat and valve become pitted, they should be reconditioned.

*e.* Level control valves. Level control valves used in plumbing systems control the liquid levels in water supply tanks, boilers, and other similar installations. These valves are actuated by a float and rod mechanism similar to the valve assembly used in water closet tanks. When the float is down, the valve is open; and when the float is up, the valve is closed. Maintenance of level control valves consists primarily of replacing floats and reconditioning the valve and valve seat when they become pitted.

*f.* Backflow preventer. The backflow preventer is a device used to prevent the backflow of a liquid. It may be used to protect potable water from demineralized water or some other undesirable liquid.

The backflow preventer, shown in figure 1-56, is designed with two check valves and a relief valve. These valves operate in such a manner that no

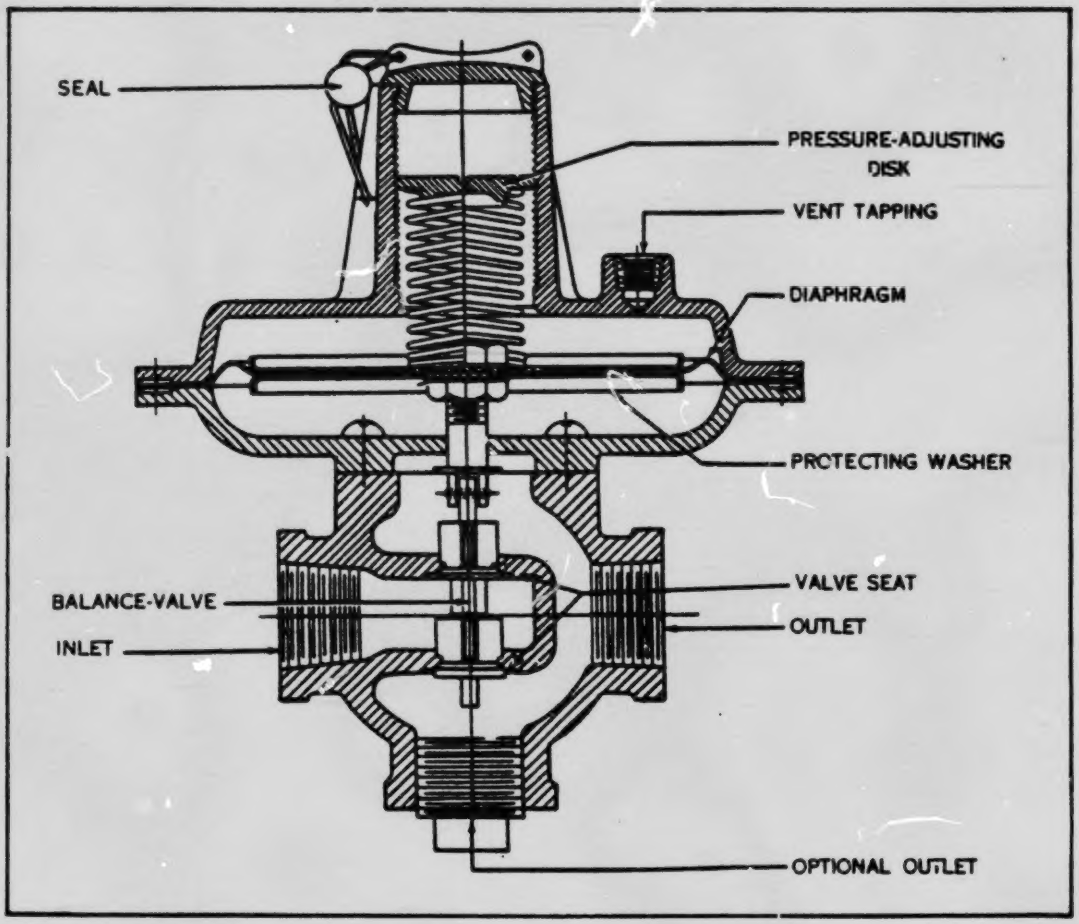


Figure 1-55. Pressure-reducing valve.

undesirable water will flow in the reverse direction beyond the middle chamber. Check valves number 1 and number 2 are spring loaded to allow water to flow in the normal direction. The relief valve is spring loaded, and the diaphragm is actuated to respond to a differential in water pressure.

To explain the operation of the backflow preventer, let's assume that a water pressure of 70 psi is entering valve number 1. Let's also assume that valve number 1 is set to reduce the water pressure from 70 psi to 62 psi as it flows into the middle chamber. The 70-psi inlet pressure at valve number 1 will be directed to the underside of the diaphragm of the relief valve. The relief valve will remain open until the differential pressure between the water pressure in the middle chamber and the bypassed inlet exceeds a set psi. When this differential pressure is reached, the inlet pressure on the diaphragm side will close the relief valve by overcoming the spring tension.

If a backflow of water occurs through open check valve number 2, the middle chamber pressure will increase to force the relief valve to the open position and allow the undesirable water to flow out of the valve into the atmosphere as waste. With the increase of pressure in the middle chamber because of backflow, the 70-psi inlet pressure will be counteracted to keep valve number 1 closed. This condition will exist until the backflow of the undesirable water ceases. Maintenance of the backflow preventer should be in accordance with the manufacturer's instruction.

*g.* Altitude valves. Altitude valves are units which control gases and liquids according to changes in altitude. These valves are very sensitive in their action. It is recommended that you follow the manufacturer's instructions when maintaining these valves.

**Exercises (411):**

Distinguish between the true and false statements by placing a T in the spaces provided for the true statements and an F in the spaces for those that are false.

____ 1. The two most commonly used gate valves are the rising and nonrising stem types.

____ 2. Gate valves are used for services where the valve is either kept fully open or closed.

____ 3. Generally the stem packing lasts only a short time on gate valves and needs constant attention.

____ 4. The volume of flow through globe valves is roughly proportional to the number of turns of the handwheel.

____ 5. The composition disc used in globe valves is available only for hot and cold services.

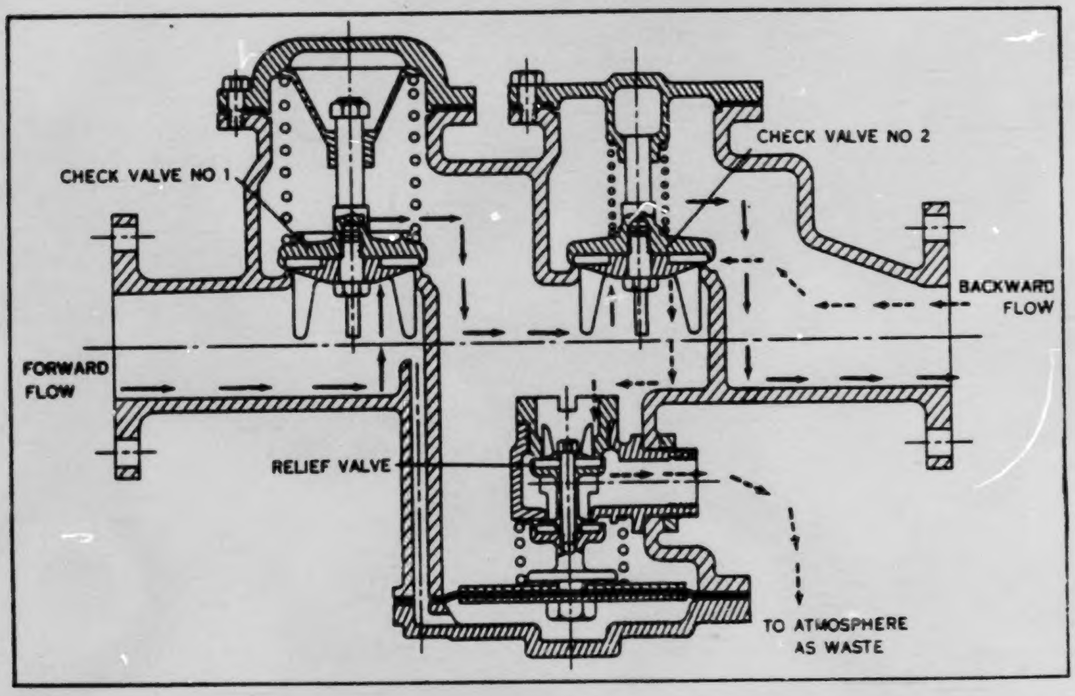


Figure 1-56. Backflow preventer.

____ 6. Check valves are marked with an arrow which indicates the direction of flow.

____ 7. Plug valves may be completely opened or closed by one-half turn of the handle.

____ 8. A float-controlled valve controls the flow of water into the flush tank.

____ 9. Leaks are the major maintenance problem of faucets.

____ 10. The thermostatically controlled mixing valve should be removed and replaced when it does not function properly.

____ 11. If the solenoid valve fails to operate, you should check for loose connections or the lack of electrical power.

____ 12. Maintenance of level valves consists primarily of tightening of loose seats.

## CHAPTER 2

# Roughing-In Water Supplies and Installing Fixtures

"WHAT? ROUGHING-IN AGAIN?" Yes, it is covered in an earlier volume, but we covered only the rough-in for the fixture vents and waste lines. As an Air Force plumber, you will also be roughing-in the water supply lines to the plumbing fixtures. So let's find out about this water supply rough-in business.

Roughing-in the water supply to the plumbing fixtures is the final operation in pipe installation before the fixtures are set. It includes installing the piping and fittings that are concealed within the walls, under the floors, or in any unfinished places, including basements. None of the fixtures can operate satisfactorily without a source of water supply. Some fixtures require more water than others, but each must be supplied with the proper amount to operate efficiently.

Determining the proper steps to take when roughing-in water supplies to a fixture requires considerable forethought and commonsense. Even an experienced plumber should not rely solely on past experience. He should refer to the specifications for the proper rough-in measurements so that the piping used will be of the correct size and will terminate at a point where it can be connected to the fixture without additional work and materials.

This chapter covers water supply requirements, types of pipes used, and rough-in procedures. It also covers water rough-in to the lavatory, bathtub and shower, urinal, and water closet. You will learn about the types, installation, and maintenance of lavatories, drinking fountains, bathtubs, showers, urinals, and water closets. Testing the water supply system is also discussed in this chapter. Draining and disassembly of a plumbing system, cleaning pipe fittings and fixtures, inspection of materials, and storage of materials and equipment are also discussed.

### 2-1. Roughing-In Water Supplies

In roughing-in water supplies to fixtures, you should know first what type of fixtures you are installing. This information may be found by referring to the blueprint for the particular job. Then refer to the manufacturer's rough-in specifications for the rough-in pipe measurements. These rough-in sheets will give you two views and the necessary measurements to locate and install the rough-in piping for the particular type of fixture.

Modern plumbing fixtures are made of either cast-iron coated with enamel or virtreous china. However, you may, find fixtures made of pressed steel and covered with enamel being used in low-cost housing projects. The traditional color for plumbing fixtures is white, but they may be procured in a number of pastel shades. The plumbing fixtures that you will be working with in the Air Force are made of cast iron and vitreous china, so handle them with care because they are easily broken.

**412. List the factors that govern the size of water service in a plumbing installation.**

**Water Supply Requirements.** Each fixture requires a certain amount of water to serve its purpose satisfactorily. If the water supply is inadequate, the fixture becomes foul, unsanitary, and injurious to the health of the people who use it. Therefore, it is important for you to install the correct sized pipe for each fixture to meet the sanitary requirements. These pipe sizes are predetermined for you by engineers. The diameters of pipe for various types of fixtures are shown in figure 2-1.

Some of the factors that affect the size of the water service in a plumbing installation are the types of flush devices used on the fixtures, pressure of the water supply to the building in pounds per square inch, length of piping in the building, number of fixtures installed in the building, and the probable use factor of these fixtures.

When a liquid flows smoothly through a pipe, particles of the liquid next to the wall have a tendency to stick to the pipe and slow down. This action retards the movement of the rest of the liquid particles in the pipe. This stream of water in the pipe can be pictured as having a series of layers of water traveling at different speeds, with the center moving fastest. The resistance to flow caused by the particles in these layers is called pipe friction. Pipe friction causes a drop in the pressure of the water. In a small pipe, this friction loss may be overcome by supplying water at a higher

| PLUMBING FIXTURE | PIPE DIAMETER (inches) |
|---|---|
| Dishwasher | 1/2 or 3/4 |
| Water closet tank | 1/2 |
| Water closet flushometer valve | 1 |
| Urinal with flushometer valve | 1/2 |
| Lavatory | 1/2 |
| Shower bath | 1/2 |
| Kitchen sink | 1/2 |
| Slop sink | 1/2 |
| Scullery sink | 3/4 |
| Laundry tray | 1/2 |
| Drinking fountain | 1/2 |
| Hot water heater (domestic) | 3/4 |
| Bathtub | 1/2 |

Figure 2-1. Water pipe sizes chart for plumbing fixtures.

pressure than otherwise would be required. In a location where higher water pressure is not available, friction loss may be reduced by increasing the size of the pipe.

**Exercises (412):**

1. List five factors that affect the size of water service in a plumbing installation.

2. What is the resistance to flow called?

3. What can be done in locations where higher pressure is not available to reduce friction loss?

**413. Given pertinent questions pertaining to roughing-in procedures, write brief answers in the blanks provided.**

**Roughing-In Procedures.** Now that you have read about how to determine the water supply capacity necessary for the fixtures to be installed, let's learn about the rough-in procedures for them.

The water supply system for a building consists of the piping, fittings, and valves that carry water from a water main into the building and also the system that supplies water to the building plumbing fixtures and equipment.

After the water main has been tapped and the corporation stop inserted, the service connection and curb stop are installed. The curb stop is usually installed between the curb and the sidewalk. The curb stop serves as a control valve for that portion of the service between the curb and the building, and as a shutoff valve for the building during repair or when the building is not to be used. After the curb stop has been installed, the water service pipe passes through the foundation wall or floor into the basement, or into the crawl space of a building without a basement. The distribution supply main is installed next. Finally, the branch lines and risers to the various fixtures are fabricated and installed.

Most rough-in is done when the skeleton of the building is under construction. It is done at this time because it is easy to run the piping to the desired points in the wall for the various fixtures. In most installations the branch lines which serve the fixtures run under the floor and between the floor joists to the point under the wall where holes are cut through the floor and soleplate to permit the pipe to reach the fixtures. The pipe risers then extend up through these holes between the studs to the height necessary to connect with the fixtures.

As you can see in figure 2-2, branch lines are connected to the distribution line by using a reducing tee, nipple, and 90° elbows The hot and cold water branch lines normally run at a slight grade, dropping toward the meter or shutoff valve. A drain cock should be installed at the low end of the grade to allow easy

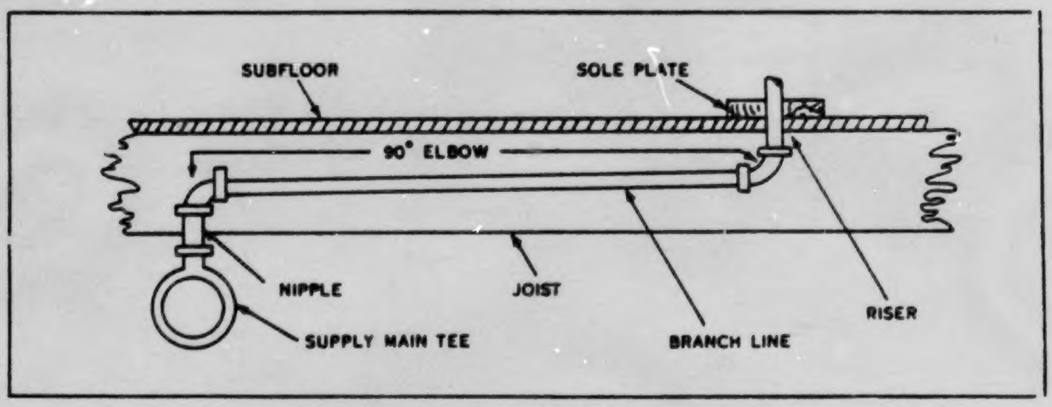


Figure 2-2. Water supply branch line.

drainage when the system is being repaired, winterized, drained, or vacated for a period of time. The branch and main lines should be supported at 10-foot intervals or closer to prevent sag and to maintain the proper slope or grade. Supports may include pipe straps, pipe hangars, wire loops, or manufactured hangers. The supports should be of the same material as the pipe on permanent installations to prevent electrolysis, which destroys metal by the action of an electrical current that develops between dissimilar metals.

The hot and cold water supply risers are connected to the branch lines by means of a 90° elbow with a pipe extending above the finished floor, as shown in figure 2-2, to a height given for the particular fixture indicated in the manufacturer's rough-in specifications. The risers should be supported with a 2" x 4" header that is cut to fit tightly between the studs, as shown in figure 2-3. The header has two holes bored through it to accommodate the risers. In this manner, the header supports the risers and keeps them in alinement with the proper spread to aline with the connections on the particular fixture.

The risers should be properly supported at each floor level, and the joints should be assembled tightly before the partitions are covered with the finished wall on new installations. The vertical fixture supply risers should be supported with pipe rests or clamps. These supports should be constructed of two pieces of heavy galvanized band iron for galvanized pipe and copper for copper tubing that is made to fit tightly around the vertical pipe. The two halves should be drawn together by bolts that pass through drilled holes on each end of the clamp. Vertical supply risers should be supported on some rigid part of the building and not on the horizontal fixture supply branches. The horizontal runs of the fixture supply risers should be graded toward the main distribution line. This type of installation will cause the water to drain out of the line and prevent freezing after the water is cut off.

It is good practice to install a gate valve in each vertical supply riser, generally at the base. With this arrangement, the water supply in any given section of the building may be shut off without affecting the water supply to the other parts of the same building.

The sudden closing of a valve or faucet at a fixture causes the flow of the water to stop suddenly and rebound against the sides of the pipe and valve. This action of the water produces a severe impulse that is heard throughout the entire piping system. Loose packing or faucet washers will produce the same effect, but in this case it is a series of shocks, and sounds like a severe rattling of pipes. This noise is called water hammer. Water causes this action because it is incompressible and cannot absorb the shock.

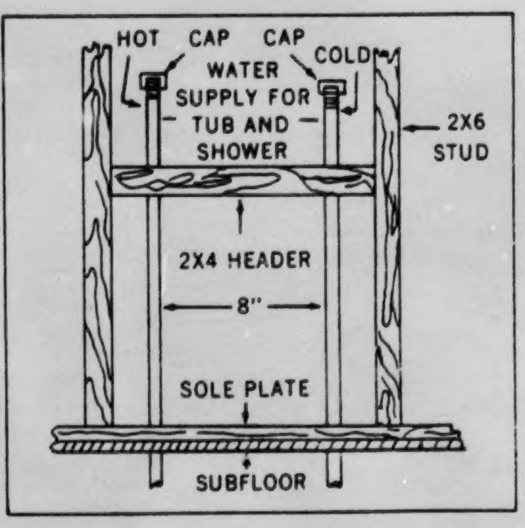


Figure 2-3. Fixture riser and header support.

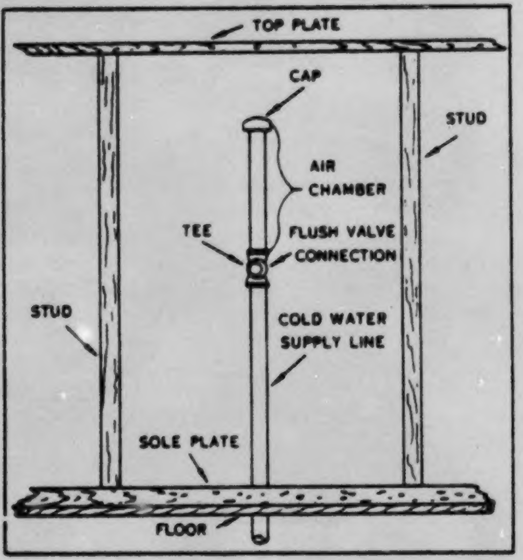


Figure 2-4. Air chamber to prevent water hammer.

An air chamber, like the one shown in figure 2-4, is installed in the system to eliminate water hammer. The air chamber, to be effective, must be placed near the quick closing valves and faucets that are responsible for the noise. The air chamber compresses with each shock of the water hammer. It absorbs the strain that would otherwise exert itself against the sides of the pipe. An effective air chamber can be made from a tee, length of pipe, and pipe cap, as shown in figure 2-4.

After the supply pipes are roughed-in and anchored, they should be capped to prevent dirt, dust, and trash from dropping into them.

**Exercises (413):**

1. Where is the curb stop usually installed?

2. At what intervals should the branch and main lines be supported?

3. How should supply risers be supported?

4. At what intervals should risers be supported?

5. What should be used to support fixture supply risers?

6. What should be installed on a supply riser to eliminate water hammer?

7. What should be installed on supply pipes after they are roughed-in to prevent entry of dirt or dust?

**414. Provided a list of statements associated with water rough-in to the lavatory, select the true statements.**

**Water Rough-In to the Lavatory.** Lavatories may be of a number of designs; however, the wall type and the trough type are the most common. The wall type is probably the most commonly used of the two. Wall type lavatories are the least expensive and the quickest

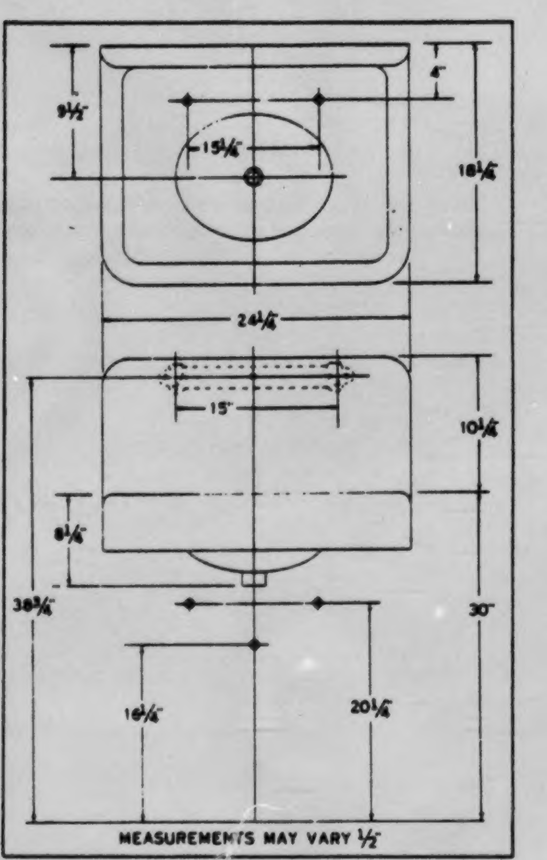


Figure 2-5. Manufacturer's specifications for a lavatory.

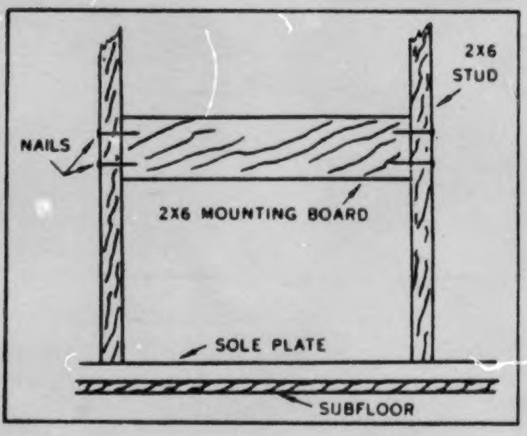


Figure 2-6. Mounting board placed between studs.

to install. Trough type lavatories are used primarily in factories, in industrial plants, and on military bases where a large number of men must be able to wash in a short time and where it is necessary to keep installation cost down.

Before you rough-in the piping for a lavatory, be sure to get the manufacturer's specification sheet for the installation. You will probably get a sheet like the one shown in figure 2-5. It will give you the rough-in dimensions you will need to do the job. You will need to know how high the lavatory is mounted from the floor, the type of pipe to use, where to position the mounting board, etc.

Wall type lavatories are mounted to a wall with special brackets that are screwed to the wall if the wall is finished with lumber. If the wall is to be finished with a soft material such as sheet rock or plaster, a mounting board must be nailed between the studs, as shown in figure 2-6, before the wall material is applied. This board serves as an anchor for the bracket screws, because the sheet rock or plaster is too soft to hold them. Mounting boards may be made from either 1-inch or 2-inch stock. Care should be taken to place the mounting board at the right place. Be sure to refer to the rough-in specifications for the proper dimensions. The mounting bracket is installed after the wall is finished.

When the mounting bracket is attached to a concrete or brick wall, it is secured by brass screws in lead sleeves which are imbedded in the wall. The holes for these sleeves are made with a star drill or drill motor and masonry bit. The lead sleeves are pushed into the holes, and the bracket screws are screwed into them. As the screws go in, they expand the sleeves and cause them to grip the sides of the hole, thereby anchoring the screws rigidly.

Through bolts may also be used to ancnor a lavatory bracket to a concrete or brick wall. In this case, the star drill or drill motor and masonry bit is used to make the hole clear through the wall. Corrosion-resisting bolts and nuts should be used to anchor the mounting bracket to the wall.

In roughing-in a lavatory you must install both the hot and cold water supply lines. The hot water line should go to the left side of the lavatory, and the cold line should go to the right. The right or left side is determined by facing the lavatory. This installation will require the assembly of two branch lines and two risers. Be sure the risers terminate at the height indicated on the manufacturer's rough-in specification sheet so that the lavatory can be connected without reworking the pipe when it is installed. After the cold and hot water lines are installed, the risers should be capped. The risers are pinched shut when copper tubing is used.

**Exercises (414):**

Select the true statements by placing a T in the appropriate spaces.

____ 1. Wall type lavatories are the least expensive and the quickest installed.

____ 2. Mounting boards may be made of 3/4" to 1" boards.

____ 3. Mounting brackets are attached to a concrete wall with brass screws and lead sleeves.

____ 4. The hot water supply should be roughed-in on the right side of the lavatory.

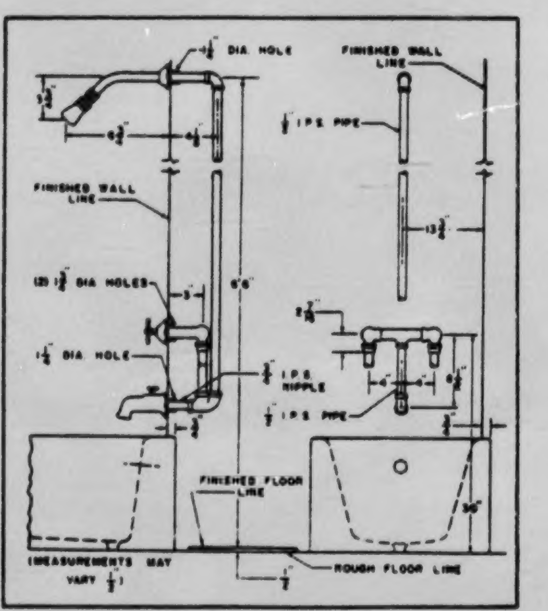


Figure 2-7. Manufacturer's rough-in for a shower and bathtub.

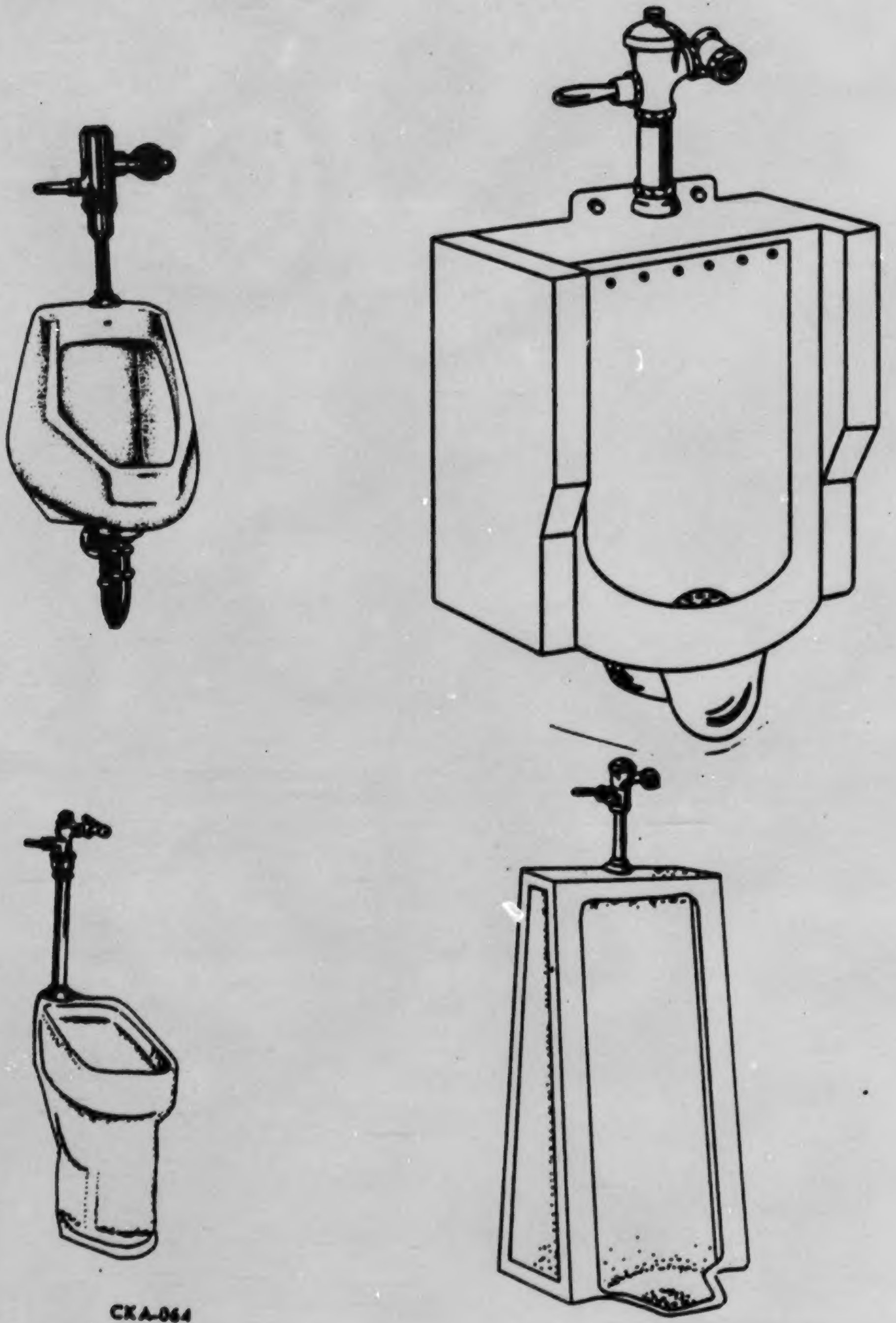

CKA-064
CKA-063

Figure 2-8. Four basic types of urinals.

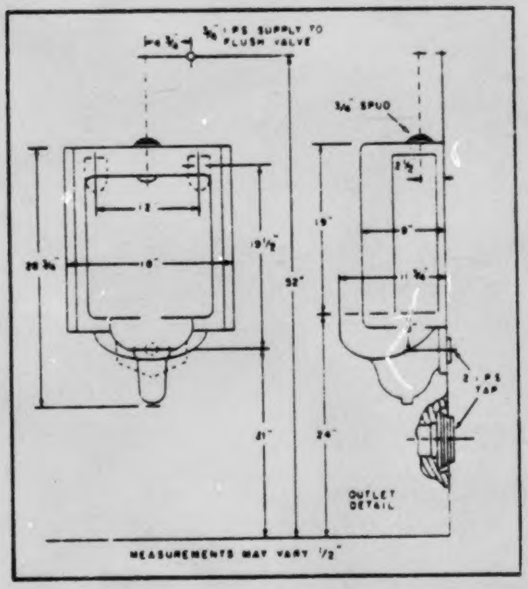


Figure 2-9. Flush type wall-hung urinal.

____ 5. Water supply risers should terminate at the height indicated on the manufacturer's rough-in specification sheet.

____ 6. After the risers have been installed, they should be capped.

### 415. Identify the correct statements concerning the roughing-in of bathtubs and showers.

**Water Rough-In to the Bathtub and Shower.** You have read about roughing-in the hot and cold water supplies to the lavatory. Now, let's learn how to rough-in the hot and cold water supplies to a bathtub with a shower combination with hot and cold mixing faucets. This combination is used for economy reasons. The tub and shower are served by the same water supply lines, and their waste is discharged into the same drain line. To rough-in the piping for the bathtub and shower, procure the manufacturer's specifications for the installation. A typical manufacturer's specification sheet for a bathtub and shower combination is shown in figure 2-7. As you can see in the illustration, the water supply risers must be 8 inches apart to connect the mixing faucet to the pipes correctly, and the center of the mixing faucet must be 30 inches above the rough floor line. These measurements are important to the plumber when roughing-in piping systems for fixtures. You will not waste as much material if you read and follow the rough-in specifications.

When roughing-in a bathtub and shower combination, you will install both the hot and cold water supply lines as you did when you roughed-in the lavatory. The hot water line should go to the left and the cold water line to the right. Roughing-in the bathtub and shower will require the installation of two branch lines and two risers, a branch line and riser for the hot water and the same for the cold water. Most of the rough-in piping for this fixture combination is installed in the wall. After the rough-in piping has been installed, close the ends of the risers by capping them or pinching them shut.

**Exercises (415):**

Identify the correct statements by placing a C in the appropriate spaces.

____ 1. The supply risers for a bathtub and shower combination should be roughed-in 8 inches apart.

____ 2. The mixing faucet must be 30 inches above the rough floor line.

____ 3. The cold water supply riser must be roughed-in on the left.

### 416. Choose the correct statements relating to roughing-in urinals.

**Water Roughing-In to the Urinal.** There are four basic types of urinals, as illustrated in figure 2-8. They are the wall-hung, trough, pedestal, and stall types. The stall type is used extensively in public buildings. The wall-hung and pedestal types are commonly used in Air Force installations. The stall and trough types are not approved for use in new construction or maintenance replacement in Air Force buildings.

To obtain rough-in measurements for a urinal you should consult the manufacturer's specification sheet. A manufacturer's specification sheet for a wall-hung urinal is shown in figure 2-9. As you can see, this sheet shows two views of the unit and gives the measurements that you need for rough-in purposes.

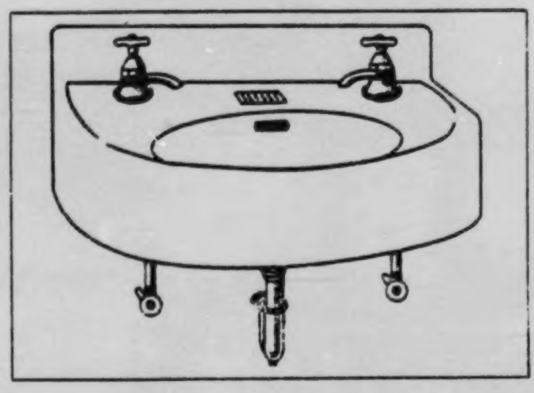


Figure 2-10. Wall-hung lavatory.

The urinal requires only a cold water supply line. You will have to assemble a branch line and a riser for it. You will also have to install a mounting board for the wall-hung urinal. Perform this operation as you did when you roughed-in the lavatory. Most urinals at the present time are flushed with a flush valve, as is the urinal in figure 2-9. As you can see in the illustration, in this case, the riser must extend up the wall 52 inches from the floor before it goes through the wall into the flush valve.

When specification sheets are not available, install the lip of the urinal from 20 to 25 inches above the finished floor line. The water supply should be 3/4 inch in diameter and the drain 2 inches in diameter. Brass bolts or screws must be used to hang urinals because of their resistance to corrosion.

**Exercises (416):**

Choose the correct statements by placing a C in the spaces provided for those that are correct.

____ 1. The trough and pedestal urinals are not approved for use in new Air Force construction.

____ 2. To obtain the rough-in measurements of a urinal, you should consult the manufacturer's specification sheet.

____ 3. The water supply pipe to a urinal should be 3/4 inch in diameter.

____ 4. Urinals should be installed with the lip 20 to 25 inches above the finished floor line.

**417. Given pertinent questions about the water rough-in for a water closet using a flushometer, write brief answers in the spaces provided.**

**Water Rough-In to the Water Closet.** Water closets require a considerable flow of water to maintain the necessary sanitation. The greatest possibility of contamination exists at these fixtures, because of the quick growth of harmful bacteria. Piping systems for water closets must be installed according to the manufacturer's specifications to increase their efficiency and minimize maintenance costs. There are a number of different types of water closets, but they are all flushed by either a tank or a flush valve. In either case, the tank or the flush valve requires a cold water supply.

To rough-in a water closet, get a manufacturer's specification sheet for a water closet equipped with a flush valve. This sheet shows two views of the water closet. You will have to assemble only one branch line and one riser for the water closet, because it uses only cold water. The riser comes up through the soleplate, extends up the partition, and terminates 24 inches above the floor. At this point it comes through the wall and connects to the flush valve mechanism.

There are no set standards that will cover the rough-in of the water supply for tank type water closets. Each design will require its own dimensions; therefore you can see how important it is to consult the manufacturer's specification sheet when roughing-in any water closet. Tank type water closets use a 1/2-inch water supply, and those using a flush valve use a 1-inch water supply.

**Exercises (417):**

1. How many views of the water closet will the manufacturer's specification show?

2. How high should the water supply for a flush valve type water closet be roughed-in above the floor?

3. What size water supply is used for tank type water closets?

4. What size water supply is used for flush valve type water closes?

5. What should be consulted before roughing-in a water closet?

## 2-2. Installing Fixtures

You have learned how to rough-in the water supply for fixtures. Now let's see how they are installed.

Each plumbing fixture must be supplied with a sufficient amount of water to operate efficiently. The waste pipe must also be of the proper capacity to carry off the water that is supplied to it quietly and quickly. Remember that if you follow the manufacturer's specifications when you install fixtures, you can't go wrong.

**418. From a list of statements, choose the correct statements pertaining to the types, installation, and maintenance of lavatories.**

**Lavatories.** Lavatories are probably the most widely used items of equipment in the plumbing field. Careful consideration should be given to the installation of these units. You must know the type of equipment required to connect them to the roughed-in plumbing that has been previously installed. The factors that affect the installation of these units are included in this section.

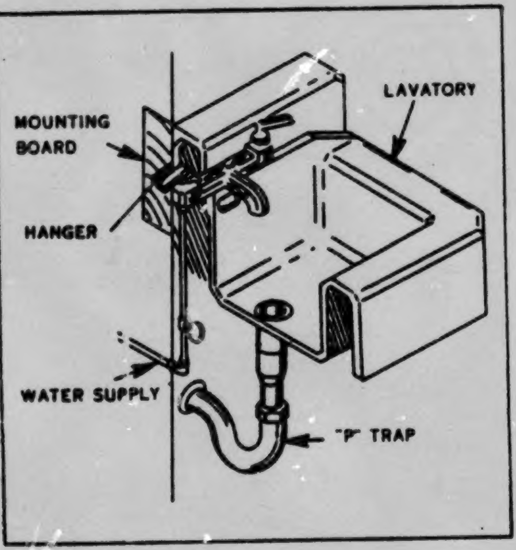


Figure 2-11. Lavatory supply connections.

*Types of lavatories.* There are many types of lavatories, but the wall-hung and pedestal types are most commonly used. A wall-hung lavatory is illustrated in figure 2-10. Lavatory bowls may be circular, square, or oval shaped. They are usually made of vitreous china but may also be made of cast iron, sheet iron, or stainless steel. Enameled cast iron is probably the most common material used, because it is more sturdy and economical. The bowls usually hold from 1 to 2 gallons of water. Normally, the lavatory is supplied with both cold and hot water. Each lavatory is provided with a P-trap in the waste pipe, because they are not designed with integral traps.

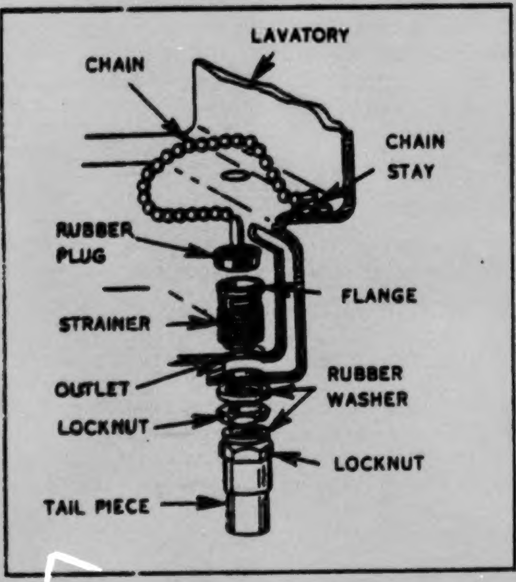


Figure 2-12. "PO" type plug drain.

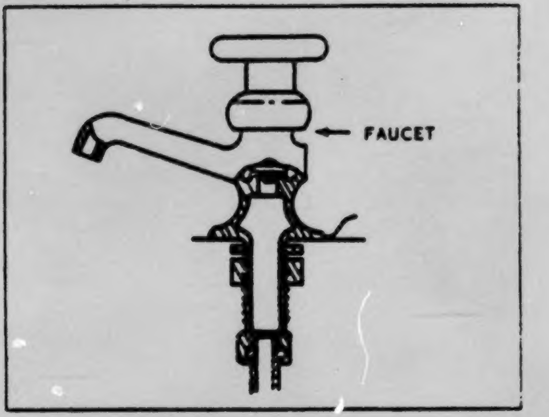


Figure 2-13. Compression faucet.

*Installation of lavatories.* Wall-hung lavatories are suspended from a bracket attached to the wall. This type of lavatory is the easiest to install and maintain. A rigid support is supplied by a 2" x 6" mounting board that is fitted between two wall studs and nailed securely in place. This mounting board is usually installed when the waste outlet and water supply lines are roughed in.

The overflow rim of a wall-hung lavatory should be 31 inches above the finished floor, unless otherwise specified by the manufacturer's specifications. When you mount the hanger for a lavatory, be sure it is level and, if possible, centered over the waste outlet. Centering the lavatory alines the tailpiece and P-trap with the roughed-in waste outlet in the wall under the lavatory, as shown in figure 2-11. The size of the waste line is usually 1¼ inches. The exposed waste and water lines are chrome plated; therefore, when you make up the joints, use a strap wrench to prevent the marring of the chrome-plated piping and fittings. The waste and supply pipes are connected after the lavatory is mounted on the wall.

The "PO" type plug drain, shown in figure 2-12, is used with some lavatories in Air Force installations. This drain is installed by placing a ring of soft putty around the waste hole in the bottom of the lavatory bowl and then inserting the flange into the hole with the threaded end projecting through the hole. A rubber washer is placed over the threads of the flange and a locknut is screwed tightly against the lavatory and gasket, which makes a tight seal. Next, the tailpiece and trap are installed with slip joint nuts and gaskets to complete the drain installation, as shown in figure 2-11.

Hot and cold water faucets are installed in the holes provided in the top of the lavatory. They may be the individual type, as shown in figure 2-13, or the combination type, which is interconnected into one common outlet with provisions for mixing or tempering the water, as shown in figure 2-11.

The faucets are sealed into the rim of the lavatory with a rubber gasket and held tight by a coupling nut which is screwed onto the shank of the valve from beneath the fixture. This coupling nut cannot be reached with an ordinary wrench, so a basin wrench must be used. The basin wrench is a right-angle pipe wrench mounted on an extension bar which extends the handle below the bottom of the lavatory bowl. It may be used to tighten as well as loosen the particular nut. The basin wrench may also be used on other nuts which are hard to get at. After the faucets have been installed, they may be connected to their respective water supply lines. Each line is connected to the faucet with a jiffy connector, shown in figure 2-14. This connector is usually made of brass tubing and is chromium plated. One end is equipped with a beveled composition washer and a compression ring. During installation, the connector is attached to the faucet by inserting it into the shank of the faucet. A leakproof joint is then made by slipping the beveled and compression washers against the faucet shank and by tightening the coupling nut with a basin wrench. The compression ring protects the beveled washer from damage as the coupling nut is tightened. The other end of the connector is fitted with the proper fitting to connect to the water supply pipe. The usual procedure is to connect the jiffy connector to the water supply first and then to the faucet. After the connections have been made, the water pressure should be turned on to check for leaks. If you discover a leak, turn the water off and repair it.

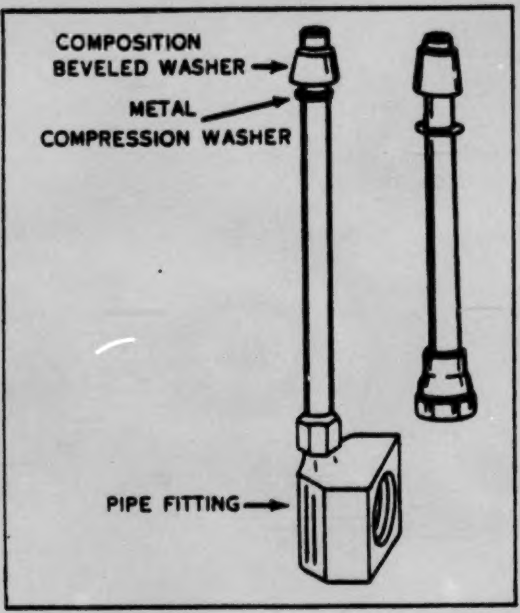


Figure 2-14. Jiffy connectors.

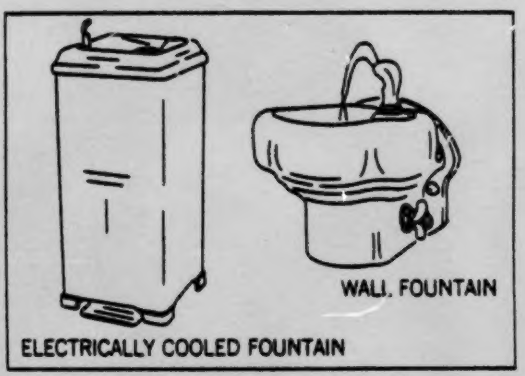


Figure 2-15. Drinking fountains used on Air Force installations.

*Maintenance of lavatories.* The maintenance of lavatories usually requires the clearing of stoppages in the strainer of the bowl and the trap of the drain pipe. If the stoppage occurs at the bowl strainer, pick it out with a hook or small spoon. If the stoppage occurs in the trap, remove the trap and clean it. If the stoppage occurs beyond the trap, remove the trap and force a sink snake down the drain pipe to clear the obstruction.

**Exercises (418):**

Choose the correct statements by placing a C in the appropriate spaces.

____ 1. The wall-hung and pedestal type lavatories are the most commonly used.
____ 2. Lavatories are only made of vitreous china.
____ 3. The overflow rim of a wall-hung lavatory should be 31 inches above the finished floor.
____ 4. The supply lines are connected to the lavatory with jiffy connectors.
____ 5. An adjustable-jawed wrench is used to tighten the coupling nut on the shank of the lavatory valve.
____ 6. Maintenance of lavatories usually requires the clearing of stoppages in the strainer and the trap.

**419. Provided a list of statements and response concerning the installation of drinking fountains match the correct response to each statement.**

**Drinking Fountains.** Drinking fountains ar installed in theaters, dining facilities, recreatior

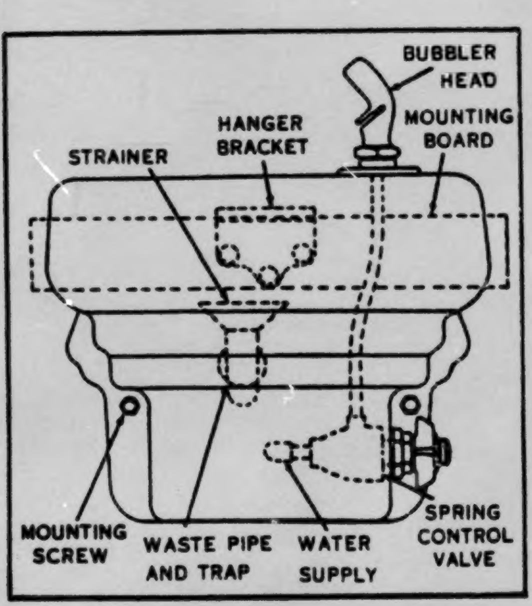

BUBBLER HEAD
HANGER BRACKET
MOUNTING BOARD
STRAINER
MOUNTING SCREW
WASTE PIPE AND TRAP
WATER SUPPLY
SPRING CONTROL VALVE

Figure 2-16. Drinking fountain installation.

rooms, and other locations to provide a quick and efficient method of supplying drinking water without the use of cups. Sanitation is the most important factor to be considered in the selection of a drinking fountain. The drinking fountain must contain a bubbler head which is located so that the user cannot touch it with his mouth. The opening should project at least three-fourths of an inch above the rim of the drinking fountain so that the waste water will not touch it. Furthermore, for the purpose of sanitation, the stream of water should be so directed that it will not fall back on the bubbler head.

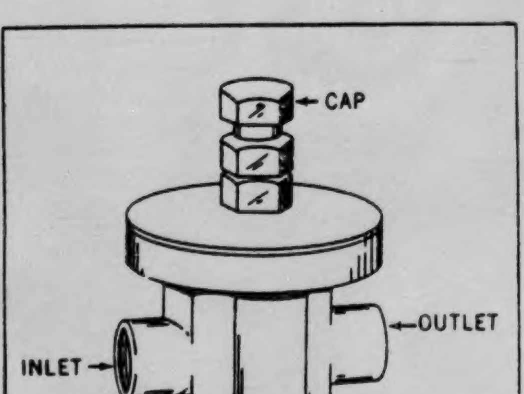

CAP
OUTLET
INLET

Figure 2-17. Automatic stream regulator valve.

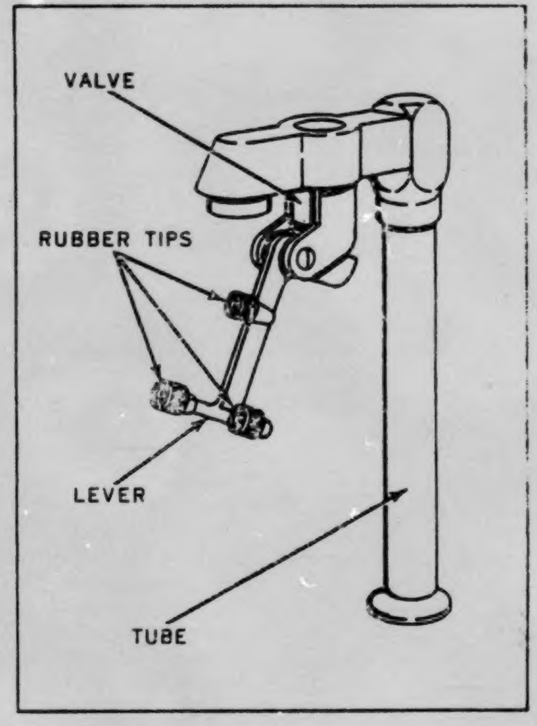

VALVE
RUBBER TIPS
LEVER
TUBE

Figure 2-18. Glass filler attachment.

*Types of drinking fountains.* Drinking fountains are usually constructed of vitreous china or porcelain. The wall-hung, pedestal, and electrically cooled are the three types of drinking fountains. The wall-hung fountain, as its name implies, is bolted to a mounting board on the wall. The pedestal fountain needs no support but stands upon its pedestal. The electrically cooled fountain contains a refrigerating unit. Water passes near the refrigerating coils and is cooled before it is supplied through the orifice of the bubbler head. The wall-hung and electrically cooled drinking

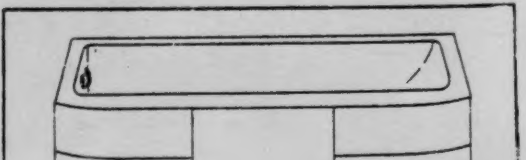


Figure 2-19. Built-in bathtub.

fountains, shown in figure 2-15, are commonly used on Air Force installations.

*Installation of drinking fountains.* The wall-hung, pedestal, and electrically cooled drinking fountains must be connected to a water supply and drainage system. About the only difference in these fountains is that the wall-hung type must be supported in a manner similar to that of a wall-hung lavatory, and the electrically cooled type must be connected to a source of electricity. The electrical and pedestal types sit on the floor and may or may not be bolted to it.

The wall-hung drinking fountain is mounted as shown in figure 2-16. As you can see in the illustration, a mounting board, hanger bracket, and mounting screws are required for its support on the wall.

A minimum size waste pipe of 1¼ inches in diameter is sufficient for drinking fountains, because they carry only clear water and do not have any grease or foreign matter flushed through them.

A 3/8-inch water supply line is required for drinking fountains. Most fountains are fitted with a self-closing water valve to eliminate the usual waste of water where fountains might otherwise be left running. Underfeeding or overshooting fountain streams are annoying to the user and cause damage to the walls and floors; therefore, most fountains are equipped with an automatic stream regulator valve, shown in figure 2-17, which provides a uniform, balanced water supply in spite of fluctuating pressure. This valve has a set screw under the cap nut that can be adjusted to obtain the desired stream of water through the orifice.

Chewing gum is often left in drinking fountains by thoughtless users. For this reason, drinking fountains should be equipped with good quality strainers to prevent the passage of chewing gum into the waste pipe.

Fountains that are located near food service lines in mess halls have installed glass fillers similar to the one shown in figure 2-18. Many of these glass fillers are fitted with a rubber-tipped, fork-shaped handle. The user can obtain a glass of water with one hand by pressing the glass against the fork handle to start the flow of water. The glass filler has an automatic stream-regulating valve similar to the one in the drinking fountain and is adjusted in the same way as the fountain.

*Maintenance of drinking fountains.* The repair of drinking fountains is generally confined to cleaning strainers, replacing valve parts, and adjusting valves. The drain line does not need clearing with a force cup very often, because the fountain is equipped with a strainer.

**Exercises (419):**

Match the statements in column A with the responses in column B by placing the appropriate letter in each space.

*Column A*

1. _____ is the minimum size waste pipe for a drinking fountain.
2. _____ is the size of the water supply for a drinking fountain.
3. _____ is the distance the bubbler head opening should extend above the overflow rim.
4. _____ is the number of different types of drinking fountains.

*Column B*

a. 3/4 inch
b. 3
c. 3/8 inch
d. 1¼ inches

**420. Choose correct statements pertaining to the installation of bathtubs and showers.**

**Bathtubs and Showers.** A combination bathtub and shower is one of the most important installations in any modern building. A bathtub and shower combination furnishes water by means of a faucet and spray nozzle. Two valves usually control the flow of water to these units. Ordinarily, when the valves are opened, the water will run into the bathtub from the bathtub faucet. However, when it is desired for the water to run through the shower head, the valves are opened as for filling the bathtub, but in addition the diverter which is located in the bathtub faucet is raised. This combination gives the bather two means of taking a bath. Some homes have the bathtub-shower combination and others have the bathtub and shower separate. The main reason for installing the bathtub and shower combination is to cut down the cost of installation.

*Types of bathtubs.* There are several types of bathtubs on the market today. Some of them are the recessed, corner-recessed, sunken, and the leg type. Tubs are made in several sizes, ranging from 4 to 6 feet in length, and are designated as right- or left-hand tubs, depending on the location of the drain. When you face the tub, if the drain is on the right end, it is a right-hand tub; if it is on the left end, it is a left-hand tub. Most bathtubs today are made of enameled cast iron or enameled pressed steel. The design most commonly used is the built-in type, shown in figure 2-19.

*Installation of bathtubs.* Modern cast-iron tubs are designed to rest on the floor and normally span an area from wall to wall. The tub sits firmly on the subfloor, and the rim of the tub is supported by a piece of 2" x 4" nailed lengthwise on the studs, as shown in figure 2-20, or supported by 2" x 4" blocks resting on the subfloor and nailed to the soleplate and studs, as shown in figure 2-21. After the tub is placed against the studs and the rim of the tub is resting on its supports, check it to insure that it is level. If you use shims to level the tub, use material that the weight of the tub will not cut or break.

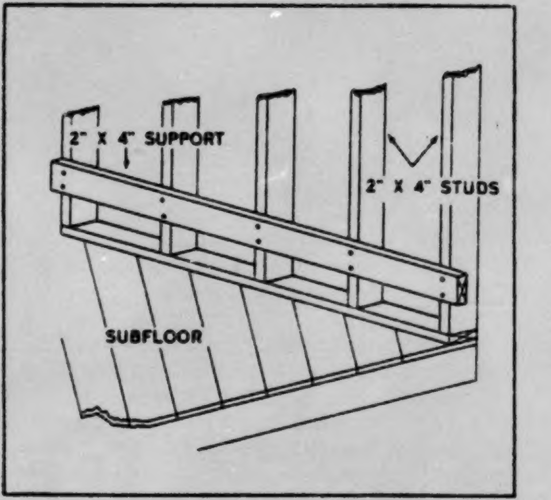


Figure 2-20. 2" x 4" used as bathtub support.

The tub drain and overflow is usually similar to the one shown in figure 2-22. The drain assembly is installed in the space provided by the studs at the end of the tub. The overflow and waste drains are made of chrome. The hidden parts are made of rough brass and brass tubing. The fittings are 1½ inches in diameter and come with a pop-up waste or a rubber stopper fastened to the overflow by a chrome chain. This drain and overflow combination is connected to the drum or P-trap with slip joint nuts and rubber washers to seal off the leaks. The drain in the bottom of the tub is sealed against leaks with plumber's putty and rubber rings.

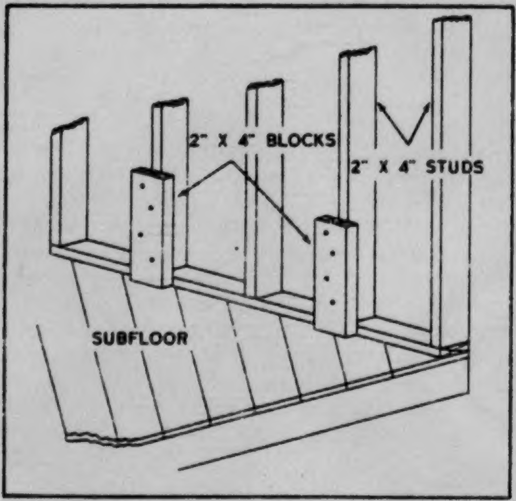


Figure 2-21. Blocks used as a bathtub support.

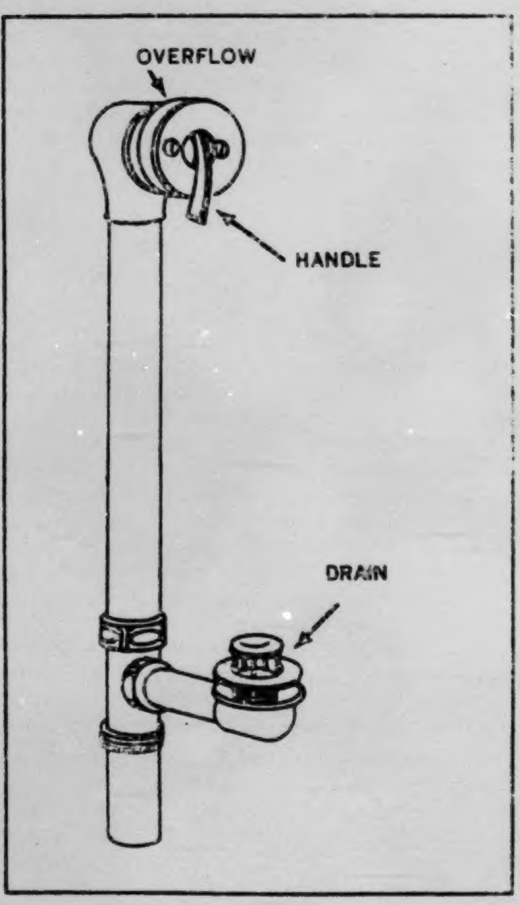


Figure 2-22. Waste drain and overflow for a bathtub.

*Maintenance of bathtubs.* The maintenance and repair of bathtubs is generally confined to the clearing of stoppages in the traps and replacing leaking washers and packings.

*Types of showers.* There are two general classes of showers used for bathing, those which discharge into the bathtub and those which discharge into a separate receptor or floor pan. The latter, strictly speaking, constitutes a shower; and the other is simply an attachment to a bathtub water supply. Both types are used in modern homes today. The only reason for the difference is economy; each accomplishes the same purpose.

*Installation of showers.* The faucet and shower combination for a bathtub and shower is connected to the hot and cold water lines that were installed when the piping was roughed in. The manufacturer's specifications should be used to determine the height of the riser. The height, however, may be specified by the user. The shower and bathtub piping and fittings installed within the wall are made of rough brass; those

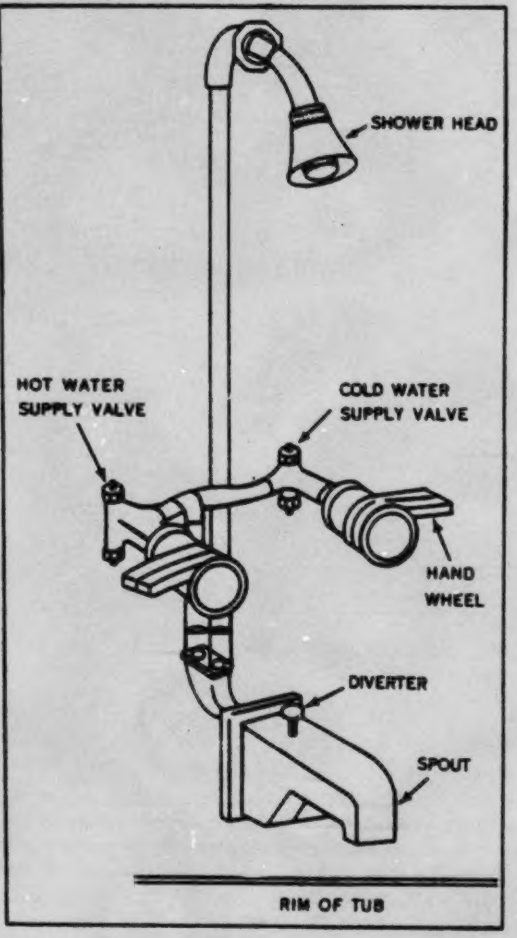


Figure 2-23. Bathtub and shower piping arrangement.

which extend through the fininshed wall have a chrome finish. A typical bathtub and shower unit is shown in figure 2-23. When you make this type of bathtub and shower installation, be sure to locate the bathtub spout from 2 to 4 inches above the rim of the tub. Spacing the spout above the rim of the tub prevents siphoning of the water from the tub in case the valve is left open and the water drops at the same time. This installation prevents cross connection between potable and nonpotable water.

A diverter is used in the down spout of the tub to divert the water up through the shower head when the shower is being used. The diverter will return to the normal position when the faucets are turned off.

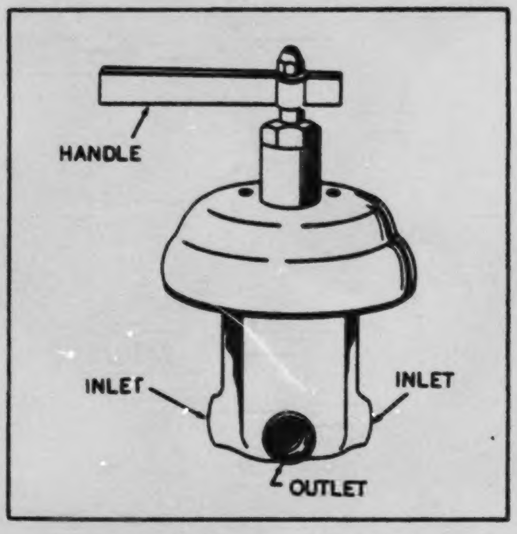


Figure 2-24. Pressure-controlled mixing valve.

The mixing [illegible] in the shower system are used to supply a unif[illegible]perature of water for the shower or tub. The temperature of the water may be regulated between the limits of the temperature of the cold water supply and the hot water supply. The equipment used to control the temperature of the water are the manual, pressure, and the thermostatic mixing valves.

*a.* Manual mixing valve. The manually controlled mixing valve actually consists of two hand-operated valves in one body with an outlet for both valves which feeds the shower head. The valves are turned by hand to control the temperature of the water. The use of manually controlled valves requires a piping arrangement similar to the one shown in figure 2-23. This water-tempering setup does not give protection against sudden changes of temperature due to slugs of

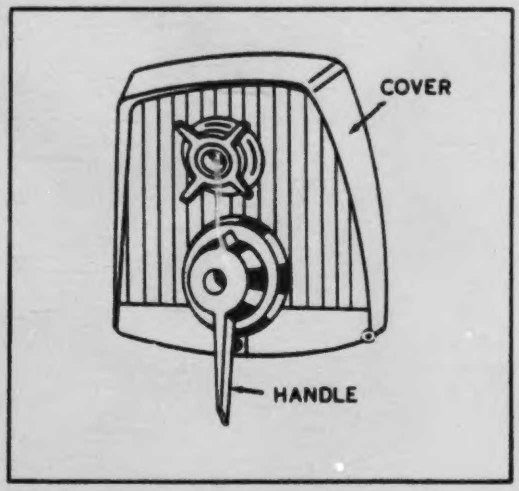


Figure 2-25. Thermostatically controlled mixing valve.

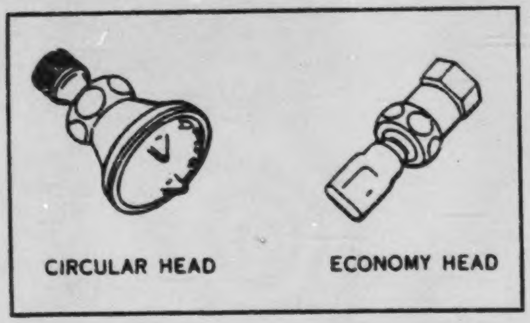


Figure 2-26. Types of shower heads.

hot or cold water caused by varying pressure or water temperature in the supply lines.

*b.* Pressure mixing valve. The pressure-controlled mixing valve, like the one shown in figure 2-24, consists of a brass mixing chamber which contains a sliding piston. The piston is provided with jets to allow hot and cold water to pass through them and mix when the handle of the valve is operated. The setting of the handle controls the water temperature by establishing the mixing ratio. A change in pressure on one side of the piston causes the piston to move. This increases the flow from the low-pressure supply to maintain a nearly constant pressure.

*c.* Thermostatic mixing valve. The thermostatically controlled mixing valve, similar to the one shown in figure 2-25, is sensitive to changes in both temperature and pressure. The temperature of the water delivered by the valve remains constant regardless of the temperature and pressure changes in the hot and cold water lines. The thermostatic mixing valve is used for showers only.

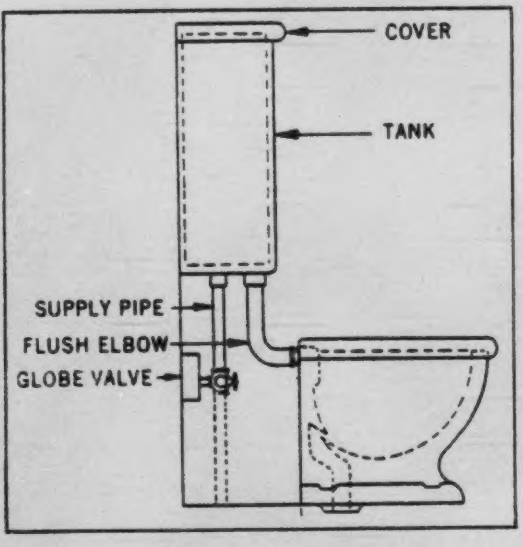


Figure 2-27. Floor-mounted water closet.

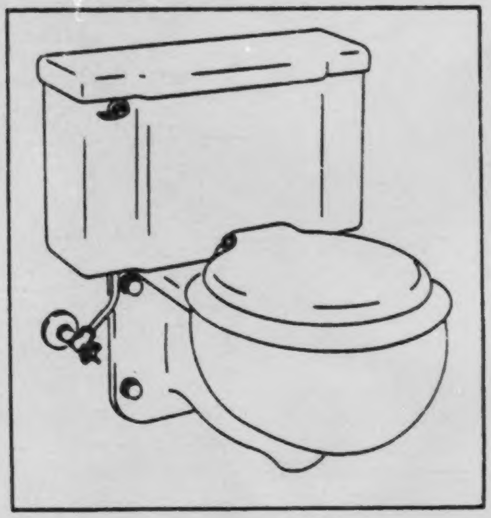


Figure 2-28. Wall-mounted water closet.

*d.* Shower heads. The shower head is attached to a 45° fitting which is mounted on a chrome pipe. There are two general types of shower heads, circular and economy. The circular spray head, shown in figure 2-26, has a restricted nozzle which provides a finer spray and uses less water. Both shower heads have a ball-and-socket joint for adjusting the direction of the spray. Shower heads are usually made of chrome- or nickel-plated brass. Newer types of shower heads are being made of plastic and have the advantage of being noncorrosive. There is a tendency for deposits to form on the shower head because of the chemical content of water. Therefore, occasional maintenance is required to keep them functioning properly.

*Maintenance of showers.* The maintenance and repair of showers consists generally of clearing stoppages and replacing faucet washers or complete valves. Normally, stoppage in a shower drain is caused by an accumulation of hair and scum. These may be cleared by removing the strainer and using a force or sink snake to dislodge them. You may find leaks in the wall sections or in the floor of a shower after a long period of time. Waterproof the deteriorated parts to stop the leaks. If the parts are corroded beyond repair, remove and replace them.

**Exercises (420):**

Choose the correct statements by placing a checkmark (√) in the spaces provided.

____ 1. When facing a bathtub, if the drain opening is on the right side it is a right-hand tub.

____ 2. The only way to support a bathtub is to nail a 2" x 4" lengthwise on the studs.

____ 3. The drain and overflow combination is connected to the drum or P-trap with slip joints and washers.

____ 4. If you were going to install a bathtub faucet, you should install the spout 2 to 4 inches above the overflow rim of the tub.

____ 5. The thermostatic mixing valve is sensitive to pressure only.

____ 6. Maintenance of showers consists of repairing faucets and clearing stoppages.

**421. Given pertinent questions pertaining to water closets, write brief answers in the spaces provided.**

**Water Closets.** Water closets are constructed so that flushing will siphon out the contents. This action also siphons the water out of the trap seal, but the trap is resealed by the refill provided from the closet tank.

The sanitation of the building will be impaired if the water closet is installed incorrectly. In other words, there is likely to be a smelly mess. Because of the sanitation problem involved and the possible damage or inconvenience caused by the improper connections, you must know how to install a water closet correctly.

*Types of water closets.* Water closets may be either floor mounted or wall mounted.

*a.* Floor-mounted water closet. The floor-mounted water closet, shown in figure 2-27, is probably the oldest type. It is the old standby and is used more than any of the others. For flushing purposes, it may be equipped with a water tank or a flush valve. The tank may be mounted on the wall or on the back end of the water closet bowl. Water closet flush valves are usually installed above the water closet bowl at a height which is convenient for the user. Water closet bowls are also constructed differently. Some use less water than others; some are quieter in their flushing action; others are constructed with large traps to reduce clogging.

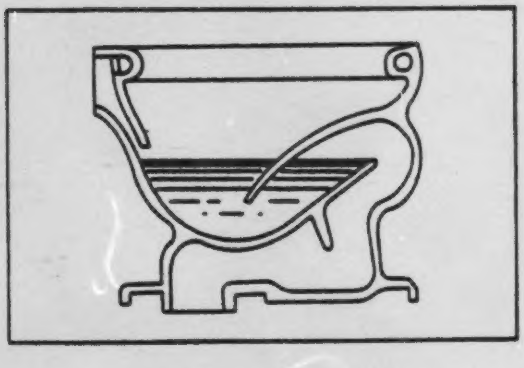


Figure 2-29. Common washdown closet bowl.

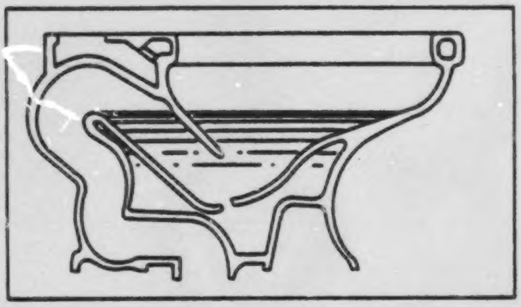


Figure 2-30. Siphon jet closet bowl.

*b.* Wall-mounted water closet. The wall-mounted water closet, illustrated in figure 2-28, operates on the same principles as the floor-mounted unit. It is designed with a tank mounted on the back of the closet bowl and is usually referred to as a close-coupled water closet. However, a wall-mounted water closet may be procured with a water flush valve instead of a tank. The flush tank is used more extensively in residences; whereas the one equipped with a flush valve is used in public places.

The wall-mounted water closet is attached to the wall with a chair carrier that is adjustable. This feature of the chair carrier permits each wall-mounted closet to be set at a uniform height from the floor.

*Water closet bowls.* There are many different types of water closet bowls. Some of them are the common washdown bowl, washdown bowl with jet, reverse trap bowl, and the siphon jet bowl. All of these water closet bowls are installed in the same manner, but they differ in their flushing action.

*a.* Washdown bowl. The washdown bowl, shown in figure 2-29, is the simplest type of water closet bowl. The trap is at the front of the bowl and is somewhat smaller than in other types, since the proper functioning of this bowl depends upon siphon action alone. During the flushing action of this water closet, the water flows from inside the rim down the side of the bowl through the integral trap and out of the fixture.

*b.* Washdown bowl with jet. The washdown bowl with a jet is similar in appearance to the common washdown bowl but has a different flushing action. The unit has a small hole in the bottom that delivers a direct jet or stream of water into the upper arm of the trap, which starts a siphoning action immediately upon the flushing of the unit.

*c.* Reverse trap bowl. The reverse trap bowl is similar to the washdown bowl except that the trap is at the rear of the bowl. This arrangement lengthens the bowl and gives it a more pleasant appearance. It holds

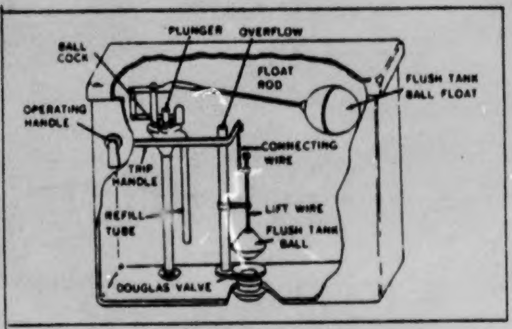


Figure 2-31. Water closet flush tank.

more water than the washdown and is quieter in operation.

*d.* Siphon jet bowl. The siphon jet bowl, shown in figure 2-30, is the most expensive, the quietest in operation, and the most efficient water closet bowl. It is similar in appearance to the reverse trap bowl, but it maintains almost a full bowl of water. Very little of the inside surface of the bowl is left uncovered when the water is at rest in the bowl.

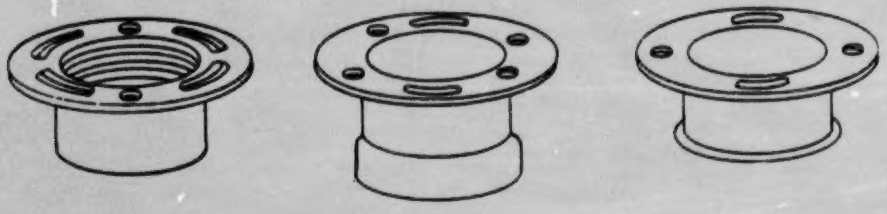
*Flushing mechanisms.* Cold water for flushing a water closet can be supplied to it by a closet tank or a flushometer type flush valve. The closet tank is used most in residential water closets. A minimum amount of water is used with this tank to flush the water closet for quiet and efficient operation. Flushometer type flush valves are more advantageous in installations where noise and economy are not particularly important.

*a.* Water closet tank. The water closet tank is made of vitreous china with a removable cover and internal working parts, as shown in figure 2-31. The primary key for the operation of the closet tank is the float valve, called a ball cock, which causes the closet tank to refill automatically and which shuts off the water when the closet tank is full. The mechanism that causes the ball cock to shut off has a flush tank ball float which moves up with the water level in the closet tank and closes the ball cock when the proper level is reached. The outlet from the closet tank into the water closet bowl is through a small unit known as a Douglas valve. The Douglas valve is a copper valve with a mechined seat. It is screwed into the bottom of the closet tank. A flush tank ball keeps the valve closed except during the actual flushing process. The flush tank ball is connected to the trip lever by a series of copper wires or rods which, when the trip handle is operated, raise the flush tank ball to begin the flushing cycle. The flush tank ball, which is full of air, remains in the raised position until the water level in the closet tank falls below it and allows gravity to return it to its seat.

*b.* Flush valves. Most of the water closets used in the Air Force are equipped with flushometer flush valves for flushing the bowls. The flushometer valve is a compact and efficient mechanism for delivering water under pressure directly into the water closet bowl. This type valve gives a quick, automatic flushing action, and the amount of water delivered can be adjusted. There are several types of flushometer valves used by the Air Force.

*Installation of water closets.* To properly install a water closet, the plumber should refer to the working drawings furnished by the manufacturers of the plumbing fixtures. Ability to read blueprints in general will enable you to visualize these simple but necessary directions. When installing a water closet, it is customary to install the closet bowl first and then the water supply units, such as the water closet tanks or water flush valves.

*a.* Setting the water closet bowl. There are a number of different methods of installing a closet bowl to the waste line; however, closet flanges, as shown in figure 2-32, are used in the installation of Air Force plumbing. The flanges are screwed or caulked to the closet bend. The edge of the flange has holes for screws to attach it to the floor. Other holes in the flange are used to bolt the water closet down when it is installed.



THREADED

FOR CALKING OVER 4" PIPE

FOR CALKING INTO HUB

Figure 2-32. Closet-bend flanges.

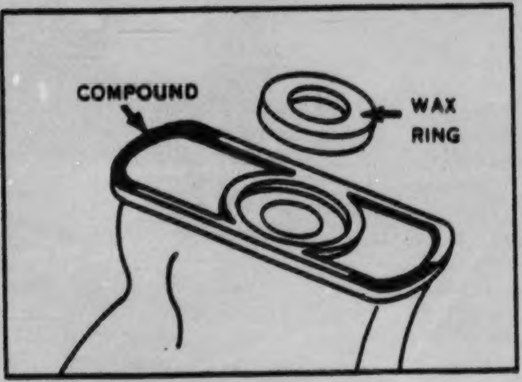


Figure 2-33. Installing compound and a wax ring gasket.

To set a bowl that is held by two closet bolts, you simply place the bolts in the flange slots provided. However if the bowl requires four bolts, place the closet over the flange on the floor and mark the location on the floor for the additional front bolts. Install the bolts into the floor at the places marked. If the floor is wood, use toilet bowl bolts, which have coarse threads on one end to be screwed into the floor and machine threads on the other. On a tile or concrete floor, set the heads of the bolts in previously prepared holes and fill them with cement to the level of the floor.

When you turn a closet bowl upside down during installation, set it on some wood strips or newspapers so that it will not get scratched. Be careful when you handle a closet bowl, because it is made of vitreous china and will break easily. After you turn the bowl upside down, place a layer of compound completely around the rim at the base and a prepared wax ring around the discharge opening, as shown in figure 2-33. In case of an emergency, you may use rubber gaskets or putty around the discharge opening of the closet bowl.

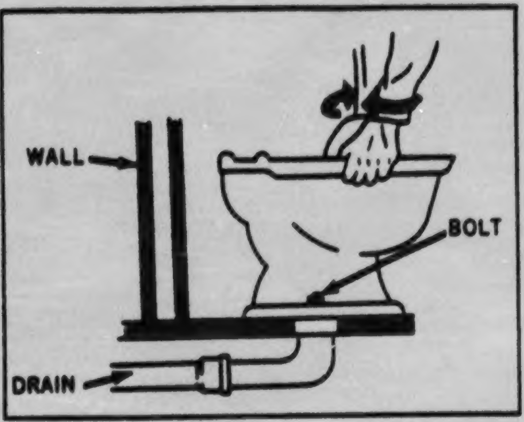


Figure 2-34. Installing a closet bowl.

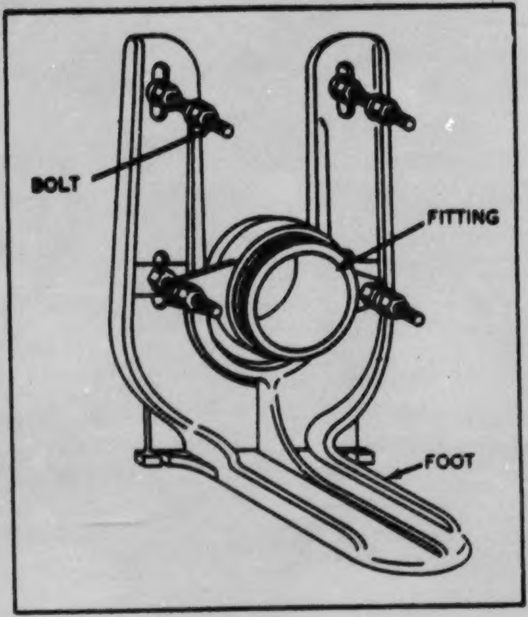


Figure 2-35. Chair carrier for a wall-hung water closet.

The compound ring should be about 1 inch thick and arranged on the outlet rim of the bowl so that it will squeeze inward. This is done by rolling the compound toward the inner edge of the rim. If the floor is not level or if the floor has been raised above the top of the closet-bend flange, use two wax rings. Now, lift the bowl and set it down over the flange, making sure that the wax ring stays in place. Continue lowering it straight down into its final position. Press down on the top center of the bowl. Use your full weight and twist it lightly to settle it into the compound and also to settle it firmly on the floor, as shown in figure 2-34. The closet bowl should be perfectly level when settled. Use a level if you are in doubt. Wedge the bowl to level it if necessary. If you use wedging, be sure it does not lift the bowl and leave air gaps in the compound around the bowl. When the bowl is squarely seated over the seals, bolt it down to a snug fit. Do not tighten the bolts too tight, because you may crack the bowl flange.

A wall-mounted water closet is attached to the wall by a chair carrier, similar to the one shown in figure 2-35. The chair carrier is positioned and bolted to the floor. The foot carries the weight of the entire closet independent of the walls and drainage connections. A standard fitting is used to make the connection between the drain and the closet bowl after the chair carrier has been bolted down. The fittings are for 4-

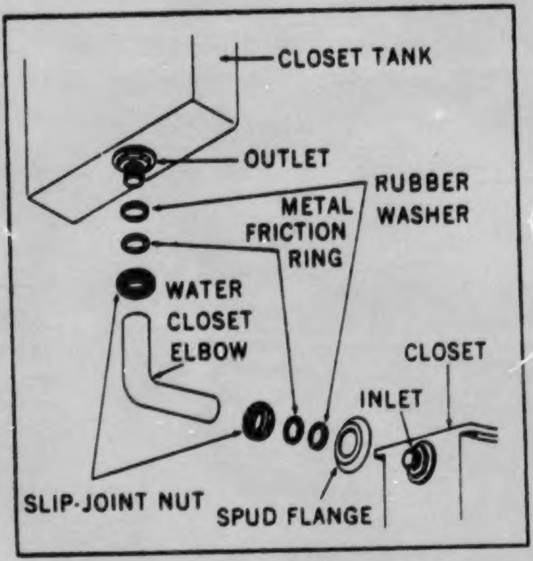


Figure 2-36. Closet tank elbow connection.

inch iron or soil pipe. The bolt holes in the chair carrier are slotted to facilitate the installation of the closet bowl.

*b.* Hanging the wall type closet water tank. A wall type closet water tank is usually installed after the closet bowl is set in place and after the wall is finished. Check the manufacturer's specifications for the height at which the wall-hung tank should be installed, referring to the particular closet with which the closet tank is a unit. Mark the height of the tank on the wall. Now, slip the water closet elbow, shown in figure 2-36, into the inlet opening on the back of the water closet bowl and tighten the slip joint nut tightly to provide a firm connection to the closet bowl. Raise the closet tank to its approximate position and insert the free end of the water closet elbow into the opening in the closet tank. Line the tank up with the bowl and fasten it to the mounting board on the wall with closet screws. Make sure the tank is level, and tighten the slip joint nuts on the water closet elbow until leakproof joints are formed in the connection between the closet tank and the water closet.

After the tank has been firmly attached to the wall, connect the water supply pipe to the tank inlet with a jiffy connector, as shown in figure 2-37. The jiffy connector used here is the same as the connector used to connect the water supply to the faucets of a lavatory.

When the water closet bowl and the closet tank are installed, flush the assembled unit several times and check for leaks. Repair the leaks if any appear and place the cover on the closet tank.

*c.* Mounting a close-coupled closet water tank. The close-coupled closet water tank sits on the back of the closet bowl and is held to the bowl by two bolts, as shown in figure 2-38. The water supply pipe is located between the bolts and drops the water directly into the bowl. A specially designed gasket is installed between the tank and bowl to make the connection waterproof. The bolts are tightened from underneath the closet bowl. Do not apply too much pressure when you tighten these bolts, because you will probably crack the bottom of the tank or the back of the bowl. The water supply pipe is installed in the tank in a manner similar to that of the wall-hung closet water tank.

*d.* Attaching a flush valve. Water closet flush valves are usually mounted next to the wall above the back end of the water closet bowl, as indicated by the manufacturer's specifications. The inlet of the valve is connected to the riser, and the valve handle is usually positioned to the left or directly toward you when you face the wall. The water supply pipe leading from the valve to the water closet bowl is usually a chromium plated pipe. A chromium compression stop with a lockshield and screwdriver slot is installed between the flush valve and the water supply for the purpose of shutting off the water when the flush valve is to be removed.

After the flush valve has been installed and the water closet bowl set, you will have to adjust the valve for proper operation. The flushing action on both the piston and diaphragm type flush valves should be set at a maximum of 10 seconds. This gives the most

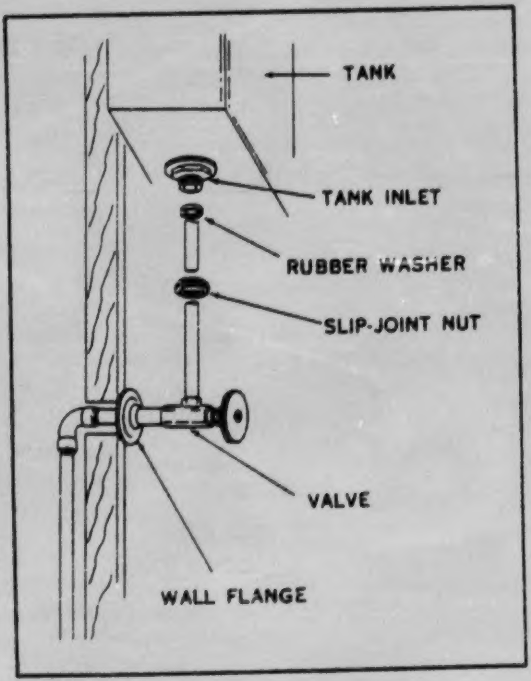


Figure 2-37. Closet tank water supply line.

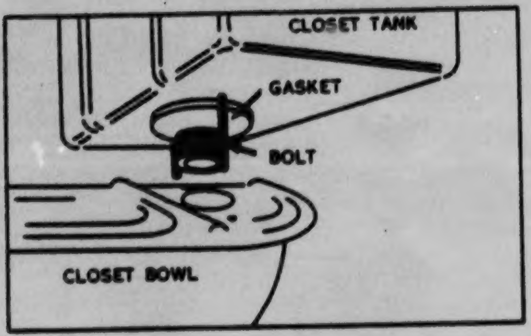


Figure 2-38. Mounting a close-coupled tank on a closet bowl.

desirable flushing time for water closets. To make this setting, adjust the screw in the top of the flushometer for the length of flushing time, and adjust the valve on the water supply for volume. After the water closet and tank or flushometer has been installed, test the system for leaks and smoothness of operation.

*Maintenance of water closets.* The maintenance of water closets is usually confined to removing stoppages in the trap of the closet bowl and the replacement of worn and corroded parts in the flush tanks and valves. Every attempt should be made to remove stoppages from water closet bowls with a force cup or closet auger first. If these methods fail, the closet bowl should be removed and turned upside down to remove the object from the traps. Occasionally a flush tank ball float may have to be replaced because it becomes water-logged as a result of a hole caused by corrosion. Corrosion may also attack the trip control wires in the tank. When they break, they must be replaced. The flush tank ball becomes worn by constant reseating of the Douglas valve and should be replaced once each year or as required. Sometimes the tank ball cock (float valve) leaks. In this case, the ball cock washers must be replaced. Be sure to readjust the tank mechanism when you replace any of the parts. The units in flush valves also wear, and must be removed and replaced. When you repair flush valves, follow the manufacturer's directions.

**Exercises (421):**

1. Name the two types of water closets.

2. What type of fitting is used to attach a wall-mounted water closet to the wall?

3. List the four flushing actions of water closet bowls.
   a.
   b.
   c.
   d.

4. What is the primary key for the operation of a water closet tank?

5. What is used to attach the water closet to the drain?

6. What is used to connect the water supply to the closet tank?

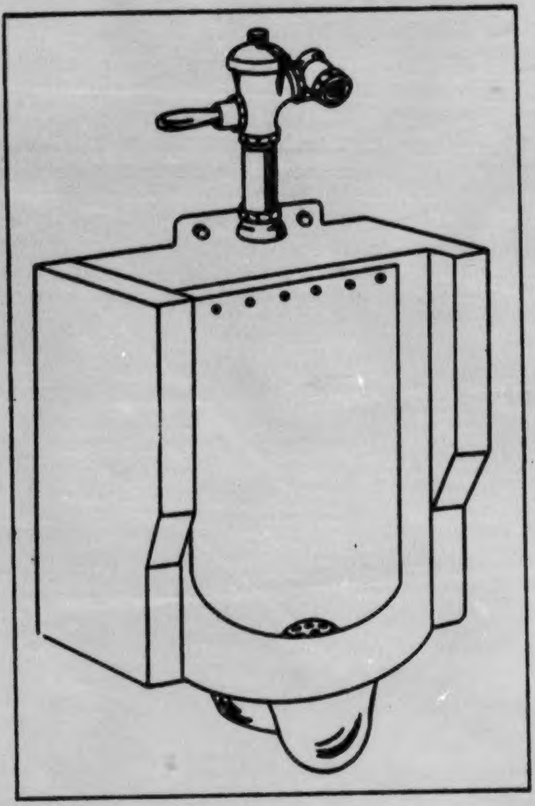


Figure 2-39. Wall-hung urinal.

7. At what maximum time should a flush valve be set?

8. What should be used to remove stoppages from water closet traps?

### 422. Identify the true statements concerning the use and installation of urinals.

**Urinals.** The latrine wall and floor areas where urinals are installed should be constructed of nonabsorbent materials to withstand damage from acidic deposits and overflow of the urinals. Urinals are constructed of vitreous china or with a glazed porcelain finish. Enameled iron will not stand up under the usage to which these fixtures are subjected, and the strong detergents used for cleaning and sanitation will eventually wear away the enameled finish.

*Types of urinals.* There are several types of urinals in use. The urinals most extensively used on military installations are the wall-hung and pedestal types. A wall-hung urinal is illustrated in figure 2-39

*Installation of urinals.* The wall-hung urinal is suspended from the wall with four bolts or screws and hung approximately 2 feet from the floor. Bolts or screws made of brass are always used to install a urinal. Iron or steel bolts are not used, because they corrode rapidly when exposed to the acids that are present around urinals. The wall-hung urinal often has an integral trap. The flushing action may consist of a washdown or a siphon jet action. The wall-hung urinal offers the possibility of severe fouling of the floor underneath it from careless users, because of its height from the floor. Therefore, when you set the wall-hung urinal, the rough-in of the waste pipe must be at the correct height so that the urinal will be easily accessible to the user. The lip of the urinal should be from 20 to 25 inches from the floor. If the rough-in already installed in the building will place the height of the urinal above or below these general measurements, the rough-in should be brought in at the proper height. When a urinal is to be hung on the wall by screws or bolts, a mounting board must be installed to provide firm support.

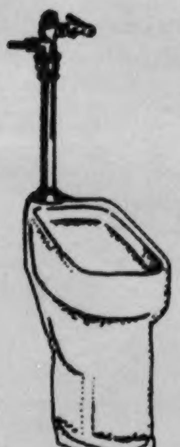

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Figure 2-40. Pedestal urinal.

The installation of a pedestal type urinal, as shown in figure 2-40, is similar to installing a floor-mounted water closet. The rough-in is made with a 4-inch closet bend and floor flange. The urinal is sealed to the floor flange by using a wax ring on the underside of the outlet. The fixture is then fastened to the floor flange with brass bolts and brass chrome-plated nuts.

The big advantage of this type of urinal is that there is less trouble with stoppages because of its large discharge opening and drain.

The cost of installation is more, but it is usually cheaper in the long run because it requires less maintenance.

*Urinal flush mechanisms.* Flushometer valves are used to flush urinals. These valves are devices which discharge a predetermined quantity of water directly from the supply line to the urinal fixtures for flushing purposes. The valves are self-closing and actuated by direct water pressure. It takes water directly from the water supply pipes to flush the fixture. These valves use less water than hand-adjusted continuous-flow units and can be operated at intervals of only a few seconds. There are several types of flush valves, including the piston and diaphragm types, which were discussed in the material on maintenance of valves under objective 411.

*Maintenance of urinals.* Urinals become fouled very rapidly. This may be minimized by cleaning the urinal every day with some type of strong soap or disinfectant. Cigarette butts, cigar butts, and chewing gum are dropped into urinals. Although the strainer catches much of this material, an occasional article slips past the strainer into the trap. These objects may clog the trap or waste pipe and cause the urinal to overflow. If this occurs, remove the obstructing material by draining the trap or using a force cup or auger. In extreme cases, you may have to remove the urinal and use a snake to clean the waste pipe.

If the valves do not operate properly, they may be

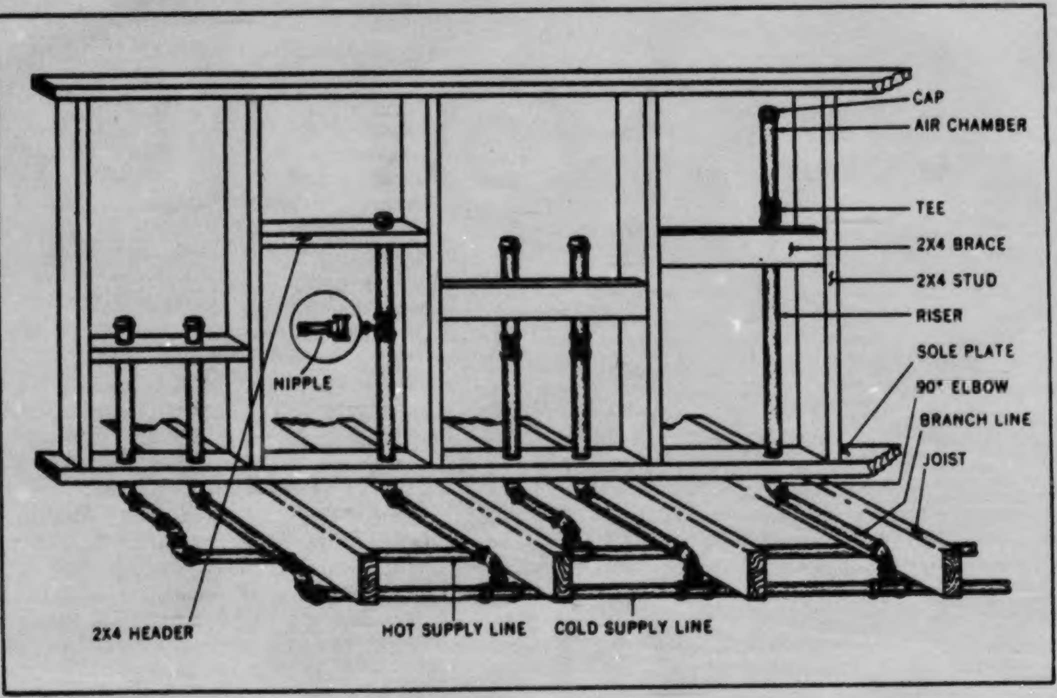

Figure 2-41. Rough-in for a water supply system.

dirty or out of adjustment. Replace the diaphragms and gaskets when necessary and adjust the valves for proper and economical operation.

If any maintenance or repair work is required on a specific model of a flush valve, it is wise to consult the manufacturer's specifications and recommendations on repair procedures and the types of materials and gaskets that should be used during the operation.

**Exercises (422):**

Identify the true statements by placing a T in the appropriate spaces.

____ 1. The most extensively used urinals in Air Force installations are the wall-hung and pedestal.
____ 2. The lip of the urinal should be from 20 to 25 inches from the floor.
____ 3. The rough-in for a pedestal urinal should have a 2-inch closet bend and floor flange.
____ 4. The piston and diaphragm flushometers are used to flush urinals.
____ 5. Urinals need very little maintenance.

## 2-3. Testing Water Supply Systems

Now that you know how to rough-in the water supply system and how to install the fixtures in the system, let's learn how to test the system for leaks.

After the water supply system has been installed and the piping checked for proper hanger alinement or evidence of shifting, the system must be tested to insure that there are no leaks present. This is especially important when piping is to be concealed in walls or ceilings. If a leaky joint is sealed in the building framing, the water could very likely run for a considerable length of time and cause extensive damage before it is discovered.

Water systems are tested at least twice before the system is put into operation. They are tested immediately after the rough-in piping is installed and again after the fixtures are installed. Both tests are important, but the rough-in is the most important, because it will disclose a water leak that would otherwise show up only after doing its damage inside a wall.

**423. Provided a list of statements associated with testing water systems, select the correct statements.**

**Testing the Water System.** The piping in a water system, both cold and hot water, must be watertight as well as airtight. The rough-in of a cold and hot water supply system is illustrated in figure 2-41. This illustration shows the fittings at which leaks may occur. It is best to check the system when the pipes are

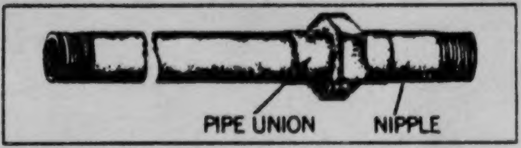

Figure 2-42. Union and nipple.

exposed, as shown in the figure. When copper tubing is used in the water system, the testing procedure is the same as for steel pipe. A leak in a system that uses copper tubing is most likely to be found at a soldered joint. Fittings that are threaded are fine grained and soft, contain a natural lubricant in the metal, and are self-sealing when properly tightened. This is why leaks are less likely at threaded joints than at soldered joints.

There are several methods that can be used to make these tests. The most common methods are the water test and air test.

*Water test.* When the water test is used, the risers and openings must be capped or plugged to hold the water in the mains and risers. The hot and cold water piping is usually tied together at a fixture so that both the cold and hot water systems may be tested. Generally, new piping is tested by the line pressure that is used in the main water lines of the installation. However, extensive pressure of 25 or 50 pounds may be added to the system by the use of a force pump. If a pressure pump is used, a pressure gage should be used to maintain the proper pressure. Do not apply excessive pressure if old piping has been connected to new piping, because it may open weak places in the old piping.

After the water pressure is applied to the system, the caps and plugs on the ends of the mains and risers should be loosened one at a time momentarily to allow the trapped air in the lines to escape. If this is not done, the air becomes compressed and holds the water back, keeping it from reaching the extreme ends of the lines, thereby preventing a true test. In case leaks develop after the test, turn the water supply off at the nearest shutoff valve and make the needed repairs.

*Air test.* There are two types of air tests, the high-pressure and the low-pressure. The type of air test used depends upon the type of system.

*a.* High-pressure test. When you make an air test on high-pressure systems, seal off the openings and pump air into the piping system. Shut off the air supply when the gage reads three times the working pressure when you are testing new construction. The pressure gage must hold the same reading for at least 10 minutes to be satisfactory.

Leaks probably can be located by listening for the sound of leaking air (hissing sound). If you cannot hear the sound, each joint must be tested individually. This procedure is accomplished by applying soap and water to the joint with a brush. Air escaping from the joint will cause bubbles to form, which will indicate the location of the leak. If the temperature is 32° F. or less, water cannot be used for this test. So, in freezing temperatures, use linseed oil instead of soapy water.

*b.* Low- or normal-pressure test. When you test a low- or normal-pressure system, add 25 to 50 pounds of air to the working pressure of the pressure air test. You may use a pressure gage or a mercury column on the low- or normal-pressure system when you make this test. The pressure is indicated by the number of inches the mercury has risen in the column. One inch of mercury equals one-half pound per square inch.

*Repairing leaks in water systems.* After you check the system for leaks, make the necessary repairs. You will find most leaks at the joints. In some cases leaks are caused by leaking valves, whereas in other cases they are caused by pinholes in the piping. Pinholes may develop during the manufacture of the pipe or because of the effects of corrosion.

*a.* Repairing a leaking joint. If a leak develops in a joint, tighten the pipe in the fitting at this point. This cannot be done easily, unless the section of pipe was assembled with a union like the one shown in figure 2-42. If there is a union in the pipe, loosen it and screw the pipe into the fitting a few turns, then retighten the union. This should stop the leak. If the pipe is not fitted with a union, you will have to cut the pipe in order to tighten the joint. But this is not all. You will have to install a union where you cut the pipe. To do this, cut the pipe with a hand-operated pipe cutter or hacksaw within 5 inches of the fitting, if possible, so that a short nipple can be used. Now, insert a new section of pipe if the system is old, or rethread the section if the system is new. Put the section and nipple together with a union after the leaking joint is tightened.

*b.* Repairing pipes. If a small pinhole or crack is found in a pipe or fitting, the section must be replaced. If there is no union on the pipe, the pipe must be cut with a pipe cutter or hacksaw within 6 inches of the fitting or valve so that a short nipple can be used. Insert a section of pipe, union, and short nipple to make up the length of pipe taken out.

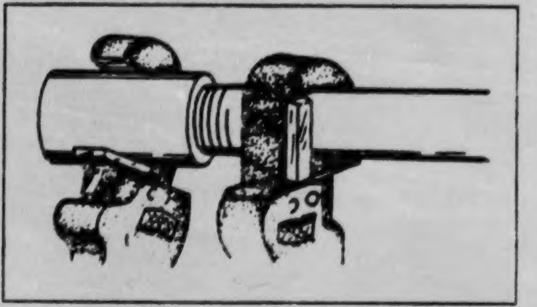

Figure 2-43. Using two wrenches to disassemble piping.

When you find a leak in a fitting, cut and remove the pipe and replace the damaged fitting. Thread the section of pipe, install the pipe and nipple in the fittings, and connect the pipe after you install the union.

*c.* Repairing leaking valves. Valve failures are generally caused by abrasive wear, abused spindles, accumulation of deposits, careless operation, damaged seating elements, destructive dust and dirt, corrosion, and insufficient lubrication.

Leaks may occur at the pipe and valve connection, the valve seat, around the stuffing box, and at the body-bonnet joint. Repairs should be made at the first sign of a leak. Usually tightening a leaking joint will correct the situation. Other repairs or remedies are the replacement of gaskets or renewable parts, repacking stuffing boxes, or regrinding valve seats.

If the valve must be replaced, you will have to cut the pipe within 6 inches of the valve so that the short section can be replaced with a standard nipple. The valve is then replaced with a new one. Thread the cut end of the pipe, replace the pipe joint and nipple, and connect the pipe together with a union.

*d.* Repairing copper tubing. When leaks occur at a soldered type joint in copper tubing, drain the tubing and resolder the joints. If compression type joints are used in the system, just tighten them with a wrench. When a section of copper tubing has to be replaced, use copper sweat or forged brass couplings, rather than a brass union, to connect two pieces of tubing the same size together.

**Exercises (423):**

Select the correct statements by placing a C in the spaces provided.

____ 1. New piping is generally tested by the line pressure used in the main water lines.

____ 2. When performing the water test, you should loosen caps and plugs one at a time to allow trapped air to escape.

____ 3. There are three types of air test used on water supply systems.

____ 4. The high-pressure air test is performed at three times the working pressure of the system.

____ 5. When you perform the high-pressure test, the gage must hold 5 minutes.

____ 6. When performing the low-pressure air test, you should add 50 to 75 pounds of pressure to the system.

____ 7. When repairing leaks in screwed joints, you should cut the pipe within 6 inches of the fitting and install a union and nipple.

## 2-4. Recovery of Plumbing Equipment

You have completed the section on testing water supply systems. Now let's complete this roughing-in of water supplies and installations of fixtures business by learning about the recovery of plumbing equipment.

At some time or other, you will be responsible for disassembling water service lines as well as waste lines to save reusable plumbing material and equipment. You must be able to disassemble pipe connections without damaging the pipes, fittings, and fixtures. You must also be able to determine if pipes, fittings, and fixtures can be reused in another installation.

**424. From a list of procedures related to draining plumbing systems, select those which are correct.**

**Draining the System.** Before a water or gas system is disassembled, it must be shut off from the water or gas supply to reduce the pressure. To drain a water supply system, close the service valve where the service pipe enters the building. This service valve is usually equipped with a drain hole through which the water drains from the building pipes after it is closed against the supply pressure. The water in the pipes may be allowed to drain through the drain hole in the valve if quick draining is not required. If quick draining is required, then the service valve should be closed and the highest faucet in the system should be opened to admit air in the system, and the lowest faucet should be opened to allow the water to escape from the system. After the water stops draining from the lower faucet, the remainder of the water in the system will drain through the drain hole in the service valve.

In some cases, if the highest faucet is not opened, or unless the system is equipped with an automatic vacuum breaker, the closing of the service valve and opening of the lowest faucet is apt to draw water into the supply system. Water may be drawn from the water closets, whose valves are operated by water pressure, and from fixtures with faucet openings below the upper edge of the bowl.

The closet tanks and water heaters must be drained individually in order to completely drain a water supply system. Closet tanks may be drained by flushing the closet with the water in the tank. The remaining water in the tank below the outlet should be removed with a sponge or cloth. The closet traps may be emptied by forcing the water out of them with a force pump or a plunger cup. The remaining water may be removed with a sponge attached to a wire.

The fires must be out before hot water heaters and similar tanks are drained. These tanks usually have a drain valve or plug at the bottom, and an air valve at the top through which air enters the tank while the water flows out of it. If the tank is not equipped with an air valve, loosen part of the piping at the top of the tank to admit the air. Connect a garden hose to the hot water tank drain valve to carry the water to the outside of the building.

Gas lines are not drained, but the shutoff valve at the meter must be closed. After you close the valve, it is a good idea to disassemble the piping at this point and cap the meter outlet line. This precaution is taken just in case someone turns on the gas while part of the pipes are disassembled. A situation of this kind could cause an explosion.

**Exercises (424):**

Indicate which of the following procedures are correct by placing a checkmark (√) in the appropriate spaces.

____ 1. To drain a building water supply system, the service valve should be closed where the pipe enters the building.

____ 2. To aid in draining the system, you should open the highest faucet after the stop and waste is shut off.

____ 3. Drain the water heater back through the cold water supply pipe.

____ 4. After the closet tank has been flushed, the remaining water should be removed with a sponge or cloth.

**425. Given questions concerned with disassembling plumbing systems, write your answers in the spaces provided.**

**Disassembly of the System.** The most logical method of pipe disassembly is to start at the highest point in the system by removing a fixture and beginning at a riser. This is just the reverse of the way the piping was installed. Another method of pipe disassembly is to start at a pipe union and remove the pipe both ways from that point. In cases when it is not desirable to start at a fixture and work back, or when a pipe union cannot be found to start disassembly from, you may have to cut the pipe at the desired location and begin disassembly either way from this point.

Be careful when you are removing fixtures so that you will not break or chip them. You must also be careful when you are removing water supply and waste pipes from fixtures, because the connections are probably corroded. Use a strap or adjustable wrench to remove any kind of chromium, brass, or copper pipes and fittings. After the pipes have been disconnected from a fixture, remove it from the wall. In some cases, the fixture may be removed by unscrewing the lag screws, whereas in others it may be lifted from its bracket. The bracket should be removed at this time and tied to the fixture. This precaution is taken to assure that you have the proper bracket when the fixture is installed again. When the fixture has been disconnected, carry it away a sufficient distance so that it will not get marred or broken during the disassembly procedure.

When you remove galvanized or black iron pipe, use two wrenches to unscrew each connection, as shown in figure 2-43. Be sure to use an adjustable wrench on hexagonal pipe fittings. Sometimes the connections may be rusted and corroded to the extent that they will not unscrew. In this case, you may have to strike the surface of the fitting with a hammer to loosen it at the threads. Do not strike cast-iron fittings too hard, because you may crack them. Cracked fittings are useless. When you unscrew threaded pipe and fittings, be sure you do not damage the pipe. The pipe wrench will damage the pipe and fittings if it is allowed to slip. This procedure is likely to mar the pipe, which causes the surface to become grooved. Marring the pipe in this way will weaken it, cause greater corrosion action at marred surfaces, and leave sharp projections which are apt to scratch and cut the hands of persons handling them. Careless disassembly can bend the pipe or damage the threads. Even though the pipes and fittings are made of tough materials, they are very easily bent and dented.

During the disassembly of copper pipe and fittings, apply heat from some type of torch to melt the solder in the joints. Every precaution must be taken to avoid starting a fire when heating the pipes and fittings that are located near the flammable structural parts of the building. Be sure that the lines are drained before you heat the pipe. In the first place, the pipe and fittings are hard to heat with water in the lines; and furthermore, when the joint is disassembled, the heated water may run out and scald you.

When you disassemble cast-iron soil pipe, you will have to remove the lead and oakum from the joints. The tools required to uncaulk a joint depend upon the location of the pipe. The operation may require the use of either a lead pickout iron and a ball peen hammer, or a torch and a metal pan to catch the melted lead from the joints.

Where the work is near a wall or some other similar construction and there is danger of a fire if a torch is used, you should use a lead pickout iron and a ball peen hammer. Removing the lead from the joint with a pickout iron is a very slow method that should be used only when necessary.

In most cases, an oxyacetylene welding torch is used to melt the lead from the caulked joints. The torch should be used as little as possible in order to minimize the chance of causing a fire. You should have a hand-pump water extinguisher within easy reach when you are melting lead joints, because the water in the building will be shut off.

Before melting the lead from the joints, place a metal catch pan under the joint to catch the lead. Later, ladle the lead into small containers to form easy-to-handle cakes or ingots for reuse. During this operation you must wear both gloves and goggles. If you are not familiar with the heating torch you are about to use, have your supervisor show you how to light it and adjust the flame to melt lead. Start melting the lead by applying the flame at the top point of the lead ring, and let it wash down to the bottom and into the pan. The hot lead assists in melting the lead as it washes down over the unmelted lead below. Melt the lead down first on one side then the other. The greatest amount of heat is at the tip of the inner cone of the flame. Your attention must be centered on the work you are doing and not on something else when you are using any type of torch. Use a sledge or similar heavy hammer to break pipe and fittings that cannot be removed by any other method. At times there is no advantage in saving a piece of pipe or fitting, because the time required to remove it or the cost of the labor plus the time would not make it worth while.

After the various pipes have been removed, remove the hangers, brackets, and other pipe anchor irons. Be sure that there are enough personnel detailed to carry the equipment when you move the sections of pipe to an outside area in order to prevent undue strain and possible injury to any of the men. The men assigned to carry the sections of pipe out of the building must wear gloves to protect their hands against cuts and burns.

**Exercises (425):**

Use the spaces provided for writing your answers to the following questions.

1. What is the most logical method of disassembling a plumbing system which has no unions?

2. Suppose you have a pipe in a crawl space which needs to be removed, and it has no union. What would you do to remove the pipe?

3. What should be used to remove lead from a caulked joint where there is danger of fire if a torch is used?

4. What safety equipment should you use when melting lead from joints?

5. Where is the greatest amount of heat in a torch flame?

**426. Identify the correct statements pertaining to inspecting and cleaning pipes, fittings, and fixtures.**

**Inspecting and Cleaning Pipes, Fittings, and Fixtures.** After the materials have been thoroughly cleaned, they should be examined to determine if they can be reused.

Since threaded pipe is the most commonly used plumbing material, let's discuss it first. When you inspect threaded pipe, examine it to determine if it is straight. If it is bent, it may be impossible to turn it when it is installed again. For this reason it should not be used. Salvage the sections of pipe that are straight. These sections may or may not be rethreaded at this time. If you determine that the pipe is reasonably straight, examine it for dents, cracks, and damaged threads.

If the pipe is not dented or cracked, and the inside is free of scale and corrosion, you may assume that the pipe is good enough for reuse. Scaled and corroded pipe should be discarded. Since the process of cutting threads on a pipe weakens it in that area, it is important that the threaded area be given a thorough inspection. Flattened, stripped, and damaged threads should be restored by cutting off the damaged threads and recutting new ones. Early failure of galvanized pipe may be expected when the galvanized coating is damaged or destroyed. This applies to the outside as well as the inside surface of the pipe.

Threaded fittings should also be carefully inspected. Those that have internal threads should be examined to determine if they have been stretched by being tightened excessively during previous use. It is not advisable to reuse stretched fittings, because it is almost certain that they will cause leaks. Internal threads in fittings should be examined to determine if they are in good shape. If the threads have been cross-threaded, the fitting should be discarded. All threads should be checked for corrosion action, such as rust. Rust eats away metal and may cause imperfect threads. Rust-damaged fittings should be discarded; however, a light coating of rust on the threads does not ruin the fitting. Threads in this condition can usually be cleaned up with threaders and taps.

Use an adjustable wrench on the hexagonal heads of the valves when you unscrew brass, bronze, and copper type valves and faucets from pipe. If you use a common pipe wrench for this operation, you will probably squeeze or squash the body ends of the valve to the point that you will not be able to thread pipe into the valve again. Furthermore, squeezing the valve body will ruin the valve by distorting the valve seat.

Reclaiming cast-iron pipe and fittings depends upon their condition. Usually, they are inspected visually and checked by sounding them out. Inspect them, and if you do not see any defects, tap them with a hammer. Remember that when you tap a pipe or fitting with a hammer, a clear ring indicates it is not cracked and is usable; a dull sound indicates it is cracked and should not be used. Usually cast-iron pipe must have a hub and a sufficient length to be usable. The extent to which pipe with or without a hub can be reused will depend upon the job. Often these short pieces can be used again.

After the fixtures have been disconnected from the supply and waste lines and the pipe and fittings disassembled, take them to a central area to be sorted.

Like items should be segregated and made ready for cleaning. Clean the fixtures, pipes, and fittings to remove rust, scale, corrosion, dirt, and other similar foreign substances. Usually, rags and a steel brush are sufficient to do the cleaning, but in some cases you must use an approved Air Force cleaner.

Place usable pipe in pipe racks for future use, and dispose of as scrap metal the pipe that is not usable. Stow the usable fittings in the proper bins, and make scrap metal of the unusable fittings.

**Exercises (426):**

Identify the correct statements by placing a checkmark (√) in the appropriate spaces.

____ 1. Scaled and corroded pipe should be discarded.

____ 2. Cross-threaded fittings should be kept for reuse.

____ 3. If a fitting has a light coat of rust on the threads, the fitting is ruined.

____ 4. An adjustable-jawed wrench should be used to unscrew valves.

____ 5. A dull ring indicates cast-iron pipe is cracked.

____ 6. Usually cast-iron pipe must have a hub and a sufficient length to be usable.

____ 7. Fixtures, pipe, and fittings must be cleaned to remove rust, scale, corrosion, and dirt.

# Copper Tubing and Brass Pipe

A FEW YEARS AGO galvanized iron was the only type of piping used in plumbing water supply systems, but today copper tubing is rapidly replacing galvanized iron pipe in modern plumbing water supply systems. Although the copper pipe or tubing costs more, its extra cost is more than offset by its not having to be replaced as often. Imagine yourself putting a low-cost iron pipe under a concrete slab foundation. A few laters later when the pipe rusts through, how much of the replacement cost do you think will be covered by the original cost savings?

In your job in the Air Force, you will be installing copper tubing. You will enjoy working with this tubing, because it is light in weight and easily installed. The joints are easily made and are as permanent as the tubing itself. Another thing you will like about copper tubing is its lack of resistance to flow. This tubing offers less resistance to water flow than galvanized iron pipe. Therefore, when you install copper tubing instead of galvanized iron pipe, you can use smaller tubing and still deliver the same amount of water to the point of discharge.

As a plumber, you will also be working with brass and copper pipe. This pipe is recommended for a wide range of domestic, commerical, industrial, and special purpose installations. You will also enjoy working with brass and copper pipe, because it is easily joined together by standard threads or by brazing. In working with brass and copper pipe, you will find them very economical because of their long life, low friction loss to water flow, and high tensile strength to withstand pressure or stress.

This chapter covers cutting, bending, and flaring copper tubing. It also covers cutting, reaming, and threading copper and brass pipe.

## 3-1. Copper Tubing

In Chapter 1 of this volume we covered the types of copper tubing and sweat soldering. Now let's learn some other methods of fabricating copper tubing. In this paragraph we will cover cutting, bending, and flaring copper tubing.

**427. Use the spaces provided to answer pertinent questions concerning the fabrication of copper tubing.**

**Fabrication of Copper Tubing.** You will be working with copper tubing frequently, because it has become very popular in the construction of plumbing systems. Therefore, you must know how to cut, anneal, and join it with special fittings.

*Cutting copper tubing.* Before you bend copper tubing, it must be cut the correct length. This operation is usually performed with a regular tube cutter, but a fine-toothed hacksaw (32 teeth to the inch) blade may be used if the tubing is clamped in a vise or a properly designed jig. After you cut the tubing, restore the inside diameter of the tubing to its original size by removing the burrs caused by the tube cutter. The burrs are usually removed with a reamer that is attached to the tube cutter, but a rattail or a half-round file may be used when a regular reamer is not available. Be sure the end of the tubing to be flared is cut off square and that the inside and outside surfaces of the tubing are smooth. Use steel wool or emery cloth to smooth the surfaces if they are rough.

*Bending copper tubing.* The copper tubing used for water lines is soft enough to be formed into desired bends where it is necessary to change the direction of a line. Copper tubing may be bent by hand, but the slightest excess pressure at one particular point will flatten or kink the tubing and render it useless. The portions of hard-tempered tubing to be bent must be annealed (softened). This can be done by heating the portion of the tubing to be bent to a dull red color with a blowtorch and then cooling it with rags soaked in water.

Copper tubing that is properly annealed can be bent by hand when sharp bends are not desired. Tubing will partially collapse during the bending process if a tube bender is not used, or if the tubing is not filled with some kind of easily removable material such as sand.

*a.* Bending tubing with sand. Probably one of the simplest methods used to bend soft copper tubing is to fill it with sand. The sand in the tubing keeps the wall

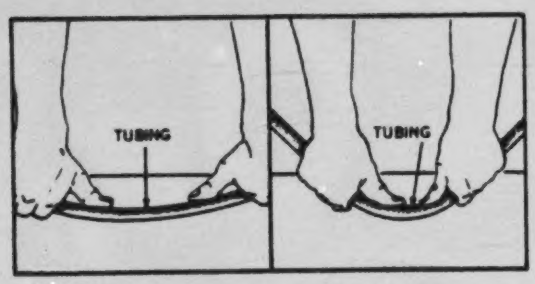

Figure 3-1. Bending tubing filled with sand.

from collapsing during the bending process. To bend the tubing after it is filled with sand, place it on a bench and grip it as shown in figure 3-1. Bend the tubing a little at a time and work your thumbs toward the center of the bend, as shown also in figure 3-1. Do not try to make the complete bend by applying pressure from only one position. This procedure will probably kink the tubing even though it is filled with sand.

*b.* Bending tubing with a bending block. Another method used in bending soft copper tubing is with the use of a bending block of the correct size, as shown in figure 3-2. The block is mounted on a table or some other solid structure. During the bending operation the end of the tubing is inserted in the loop, and by using both hands the tubing is gradually formed over the contour of the block.

*c.* Bending tubing with a spring. Still another method that is used by the plumber to bend soft copper tubing without buckling it is to use a flexible bending spring. This operation is performed by placing the correct size of flexible bending spring over the tubing, and gradually forming it with the thumbs while the tubing is held against a table or solid flat surface, as shown in figure 3-3.

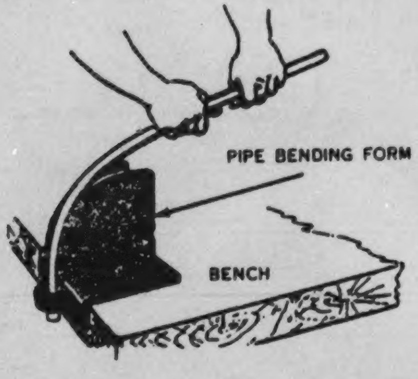

Figure 3-2. Bending tubing over a block.

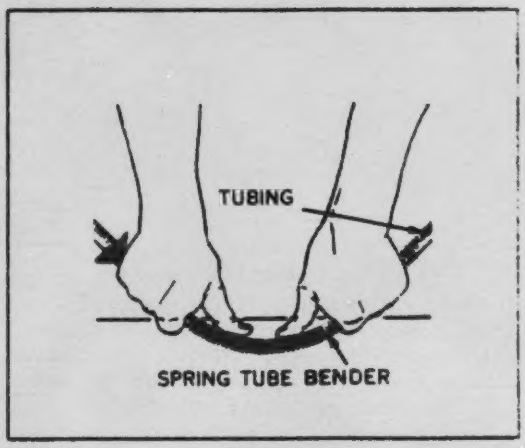

Figure 3-3. Bending tubing using a spring.

*d.* Bending tubing with tube benders. The tube benders are considered the most practical way to bend copper tubing. Benders for soft copper tubing are manufactured in many different sizes and types. The proper method for using the tube bender is illustrated in figure 3-4. When you place tubing in the bender, raise the right handle of the bender as far as it will go so that it rests in a horizontal position, as shown in figure 3-4,A. Raise the clip and place the tubing in the space between the handle slide block and ~~the~~ bending form. Now, place the clip over the tubing and turn the

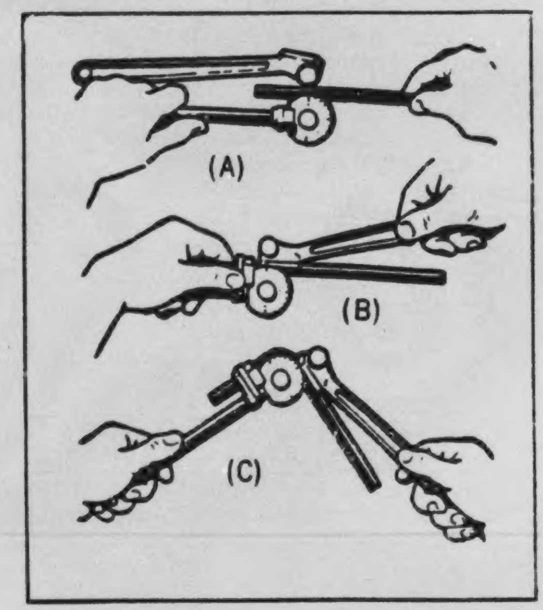

Figure 3-4. Bending tubing with a tube bender.

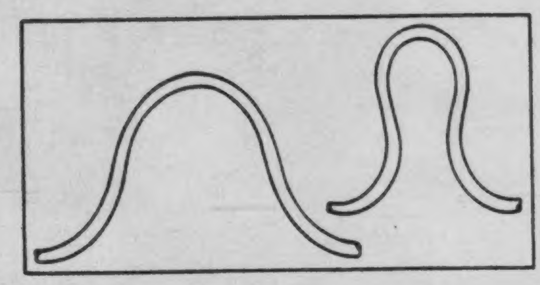

Figure 3-5. Expansion loops.

handle slide bar about its pin and to the right, as shown in figure 3-4,B. Note that the zero mark on the bending form will coincide with the mark on the slide bar. Next, continue to turn the handle to the right (clockwise), as shown in figure 3-4,C, until the tubing is bent to the desired angle. You may make bends of any angle up to 180° with the tube bender.

To remove the bent tubing from the bender, lift the handle slide bar back to its horizontal position and raise the clip. This frees the tubing so that it can be removed from the bender.

*Expansion loops.* Expansion loops are installed in copper tubing water supply systems to allow for vibration, and expansion and contraction due to temperature changes. Two examples of expansion loops that are made with tube benders are shown in figure 3-5.

*Flaring copper tubing.* One easy and satisfactory method of joining copper tubing is to flare the ends of the tubing and press the flared end against the tapered surface on the fitting. Then screw the compression nut up tight over the end of the fitting, as shown in figure 3-6. An advantage of this type of connection is that it is easily disassembled when it becomes necessary to make repairs. The only thing you have to do to disassemble this connection is to select the correct size wrench, unscrew the compression nut that makes up the compression type connection, and separate the fittings.

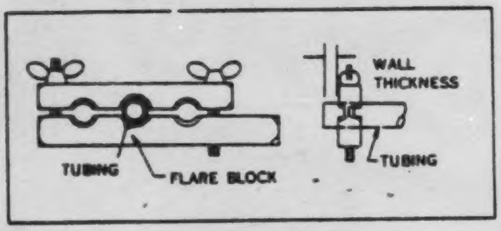

Figure 3-7. Placing tubing in a flaring block.

When you make a flare on copper tubing, you must take every precaution to produce an airtight and watertight joint. First, measure and cut the tubing to the proper length with a tube cutter or hacksaw. Then remove the burr within the pipe and clean the surface to be flared with emery cloth or steel wool. Copper tubing can be flared with a flare block or with a plug type flare tool.

*a.* Flaring copper tubing with a flaring block. Before a flare is made on tubing, slip the compression nut on the tubing and insert the end of the tubing into the correct size hole in the flaring block. Then extend the end of the tubing above the face of the block the wall thickness of the tubing, as shown in figure 3-7. This procedure allows enough tubing to spread over the taper of the fitting. Next, attach the clamp to the flare block and center the flaring face over the end of the tubing, as shown in figure 3-8. Force the flaring face against the flaring block by rotating the handle on the clamp clockwise. This causes the end of the tubing to expand just enough to fit into the compression nut and over the end of the fitting.

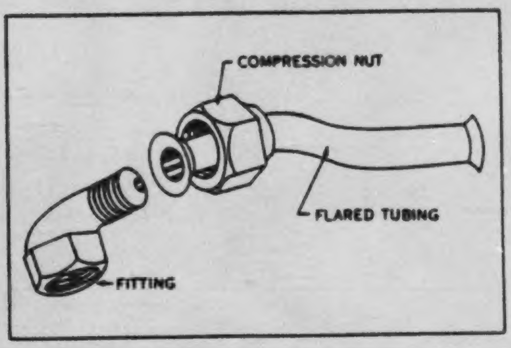

Figure 3-6. Flared tubing, compression nut, and fitting.

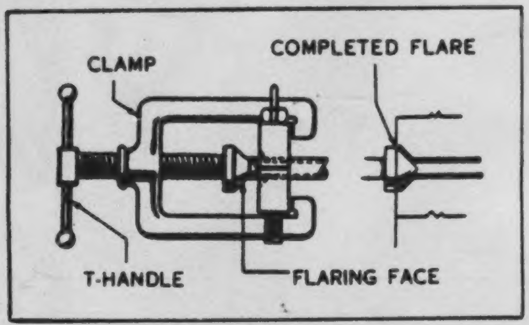

Figure 3-8. Positioning the clamp and making the flare.

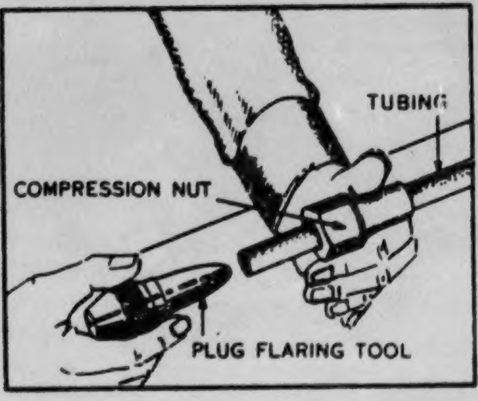

Figure 3-9. Putting the flare plug into the tubing.

*b.* Flaring copper tubing with a flaring plug. Flaring tubing with a plug type flaring tool forms the same type flare as that formed by the flaring block. As in the previous flaring method, the tubing must be cut the proper length and the burrs removed. Slip the compression nut over the end of the tubing and insert the plug type flaring tool into the end of the tubing, as shown in figure 3-9. Now, hold the tubing in your left hand and strike the end of the plug with a ball peen hammer, as shown in figure 3-10, until the desired flare is formed. It is important when you are making the flare on the tubing to check and be sure that you do not expand the flare larger than the inside of the compression nut. The flare should slip freely into the compression nut when it is properly formed.

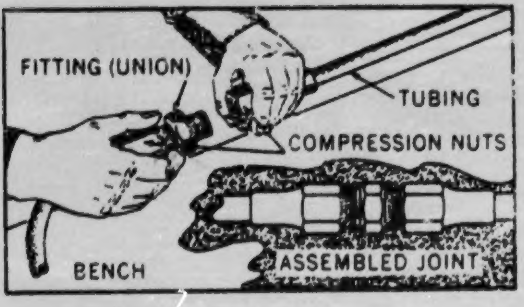

Figure 3-11. Assembly of a flared joint.

*c.* Assembly of a joint. After the tubing has been properly flared, assembly of the joint is simple. To make the joint requires a fitting that is threaded and formed on both ends to receive the flare of the tubing. Some fittings are designed with only one end to receive the flare, whereas others have a regular tapered pipe thread to fit the threads in a casting or pipe. When the proper fitting is obtained, place the flare against the fitting, as shown in figure 3-11. Next, slip the compression nut against the flare and screw it on the fitting. This operation squeezes the flare of the pipe between the fitting and compression nut, as shown in figure 3-12, making a watertight and airtight joint. When these joints are properly tightened with two wrenches they will withstand a pressure of 3000 pounds per square inch.

Wrenches that are used to tighten these joints should fit snugly to avoid damaging the connection. No tool should be used that will mar or scar either the tubing or fittings. Care must be exercised during the tightening process to prevent stripping of the threads. It is always advisable to use two wrenches when tightening or loosening these fittings to prevent twisting the tubing. It is not necessary to use excessive pressure when tightening these connections, because copper and brass fittings are soft and the metals contain a certain amount of lubricant of their own which seals them together with a minimum amount of pressure.

*Types of flared fittings.* There are many types of flared fittings that the plumber can use when he is installing a water supply system using copper tubing. Some of the flared fittings that are available are illustrated in figure 3-13.

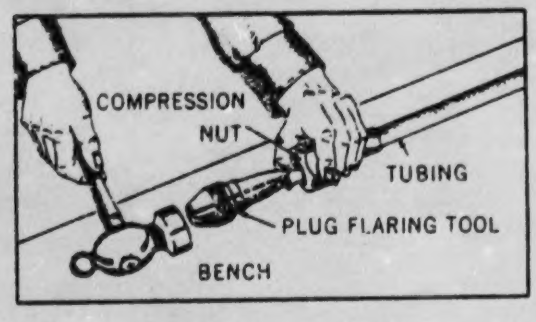

Figure 3-10. Hitting the flare plug with a ballpeen hammer.

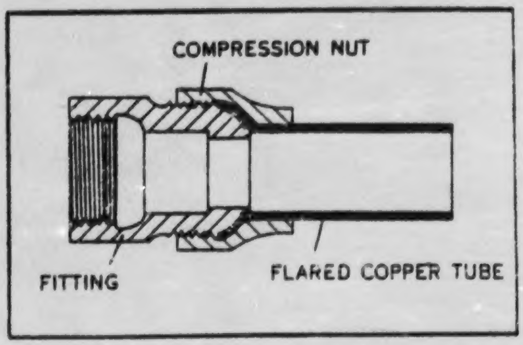

Figure 3-12. Cross section of a flared fitting.

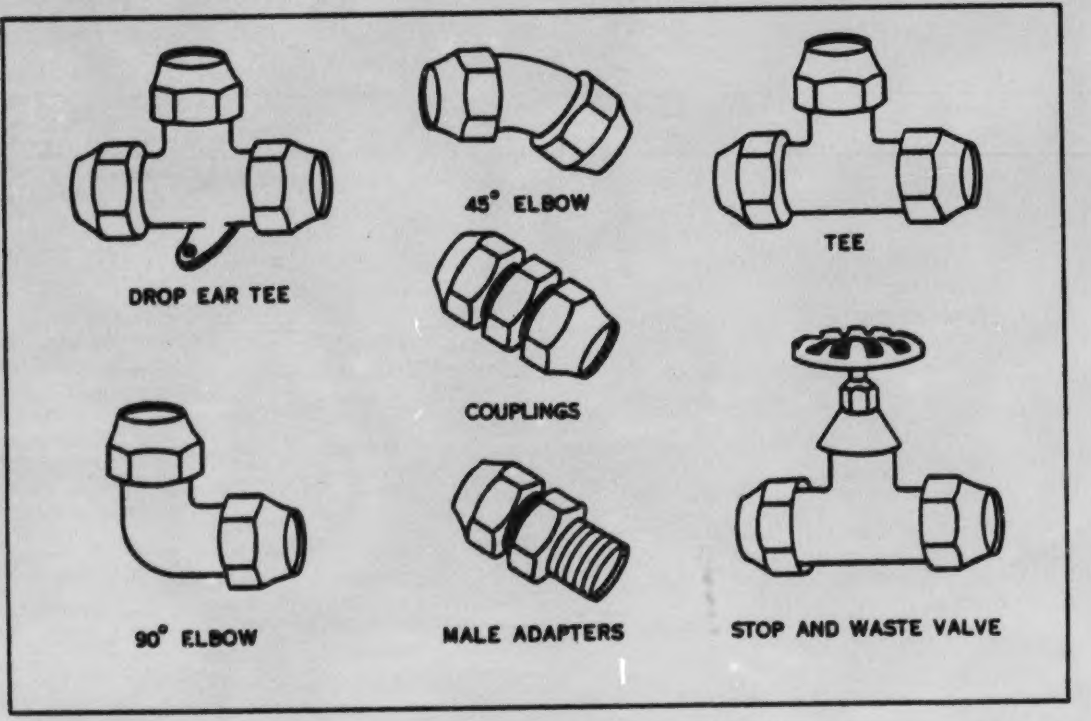
DROP EAR TEE
45° ELBOW
TEE
COUPLINGS
90° ELBOW
MALE ADAPTERS
STOP AND WASTE VALVE

Figure 3-13. Types of flared fittings.

*Swaging*. Swaging is the process by which the end of the one piece of tubing is stretched or expanded in order that the end of another piece of tubing of the same size will fit into it. (See figure 3-14.) The joint will then be sealed by soldering. By swaging the use of a fitting is eliminated.

The most important factor in joining tubing is to have proper clearances between the parts. An easy slip fit with the tubing should approximate the range of .0015 to .005 inch. To insure proper centering of the male part, insert it so as to evenly contact the shoulder of the swaged member. This insures a uniform

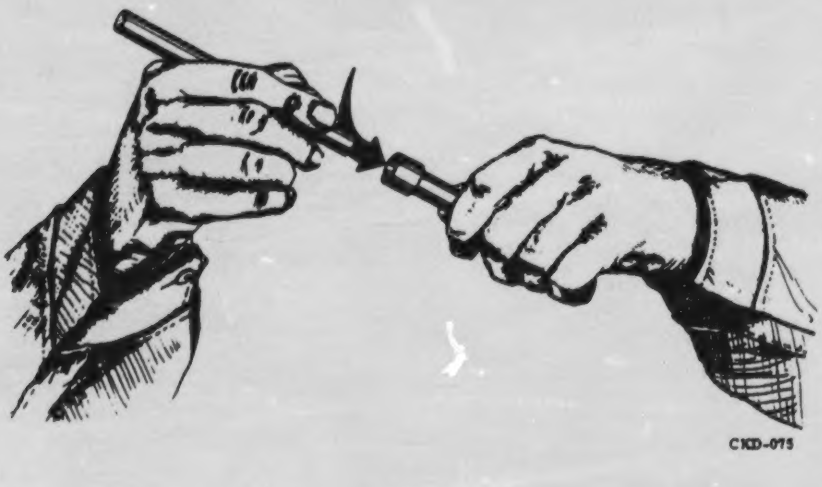

Figure 3-14. Swaging.

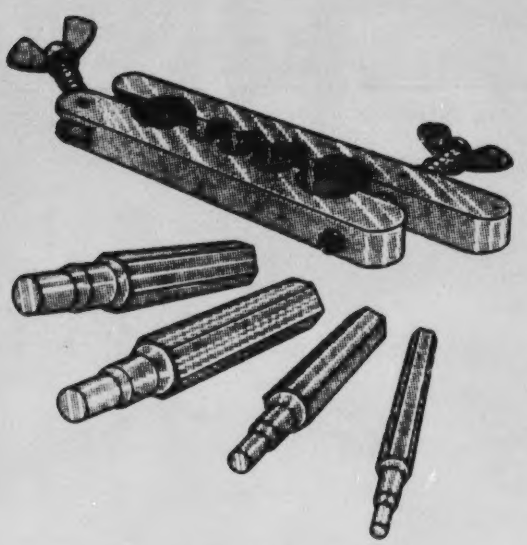

Figure 3-15. Swaging kit.

distribution of the solder with no voids and prevents the solder from dripping into the inside of the tubing, where it could cause a restriction in the tubing or even equipment damage.

Swaging can be used in close places, where there is not room for fittings. A good swage connection will reduce the possibilities of leaks.

The swaging kit consists of a swaging punch and a swaging block as illustrated in figure 3-15. The swaging punch has a small portion (called a pilot) which fits easily into the inside of the tubing and a tapered lead which connects this pilot with an enlarged portion that is slightly larger than the outside diameter of the tube.

Swaging should be accomplished as follows:

- Use back side of block (side opposite bevel).
- Clamp tube into proper size hole in block.
- Extend tube above block a distance equal to the distance from the bottom of the swaging punch to the top of the bevel, as illustrated in figure 3-16.
- Hold block firmly in hand.
- Using a hammer, drive the swaging punch into the tube (swaging punch should be turned slightly after each stroke).

The completed swage will have an inside diameter slightly larger than the original outside diameter of the tube and should always have a depth at least equal to the original outside diameter.

A swage should not be made within 1 inch of the point where a flare or a bend is located. The swaged portion of the tubing will have a double thickness, making it very difficult to bend. In flaring, it may be impossible to slip the flare nut back far enough on the tube to properly clamp the tube into the flaring block.

If swaging is properly accomplished, it will make a connection stronger than the tubing itself.

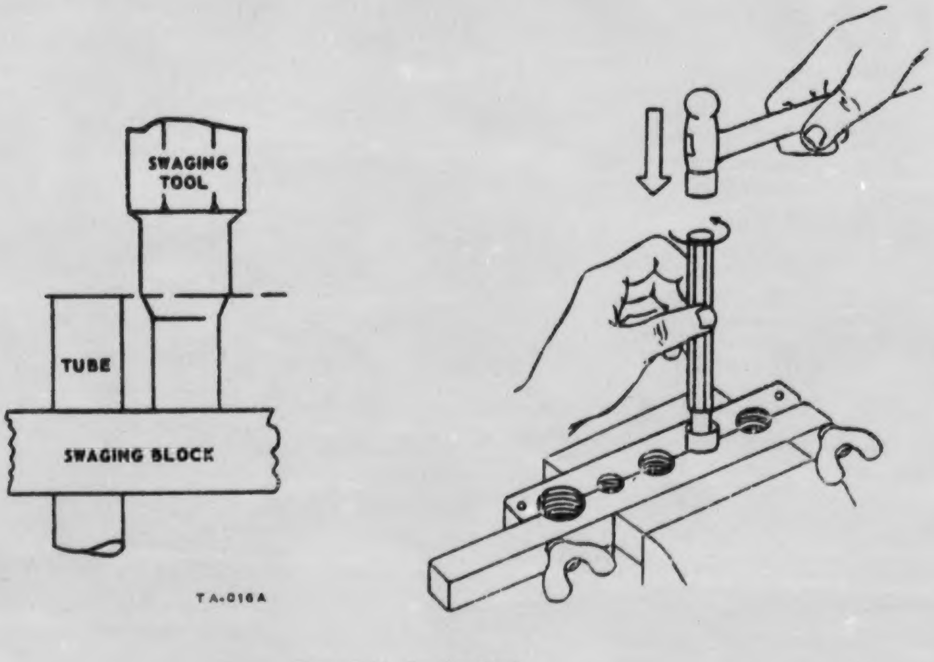

Figure 3-16. Swaging block.

**Exercises (427):**

1. When a hacksaw is used to cut copper tubing, how many teeth per inch should the hacksaw blade have?

2. What should be done to hard-tempered copper tubing before it is bent?

3. What is the purpose of expansion loops in copper tubing water supply systems?

4. What is the advantage of having a system with flared connections?

5. How far should the tubing be extended through the face of the flaring block to make a flare?

6. When flared connections are properly made, how much pressure will they stand?

7. How is a swaged joint sealed?

## 3-2. Copper and Brass Pipe

You have just completed the section on fabrication of copper tubing. Next, let's wind up this fabrication business by learning how to fabricate copper and brass pipe.

### 428. Given a list of statements pertaining to fabrication of copper and brass pipe, select the correct statements.

**Fabrication of Copper and Brass Pipe.** Copper and brass pipes are used in plumbing systems where there is danger of excessive corrosion of steel or wrought-iron pipe. Brass and copper pipes are available in various sizes and may be cut, bent, and threaded the same as steel pipe except for a slight variation in the method.

*Cutting and reaming copper and brass pipes.* Brass and copper pipes may be cut with a conventional wheel cutter, hacksaw, or a knife, and copper pipes are of softer and more ductile metal than iron or steel. A fairly heavy burr tends to form when they are cut with iron or steel pipe tools. As a means of overcoming this tendency, the conventional three-wheel pipe cutter can be equipped with thin blades that will reduce the size of the burr and also speed up cutting. A very satisfactory tool used to cut brass or copper pipe has one thin blade and two wide rollers. This tool keeps the burr within reasonable limits.

A hacksaw may also be used without damaging the pipe or forming a pronounced burr, but you must be sure that the cut is made square across the end of the pipe. A blade with 24 teeth to the inch is recommended. This method of cutting pipe is slow and involves a considerable amount of labor; therefore, it is not common practice.

Knife cutters are recommended for cutting pipe over 2 inches in diameter. They are fast, accurate, and produce no burrs. The self-alining guides on the knife cutter assure a square cut, which is necessary for proper threading.

The burr left by the ordinary pipe-cutting tool usually restricts the water-carrying capacity of the pipe to a great extent. For this reason, brass or copper pipe should always be thoroughly reamed before it is threaded. If the pipe is not reamed, a restriction will form where impurities in the water may build up and eventually entirely block the flow of water through the pipe. Tests made on a 1-inch-diameter pipe which was not reamed indicated a reduction in the inside diameter of nearly 20 percent. Burrs left in smaller sized pipe would show an even greater retarding effect on the flow of water.

Small pipe may be reamed with a brace-and-bit type of tool. For larger sizes, a ratchet reamer can be used to better advantage. A slight bevel, left after removing the burr, materially aids the flow of water through the pipe and helps to reduce frictional resistance.

*Threading copper and brass pipes.* The dies used for threading brass and copper pipe should be clean and sharp. Dull tools, broken die teeth, or grit and chips jammed in the die holder will cause the die to tear the threads so that they will not be tight when assembled. Furthermore, the use of excessive force when assembling joints will not prevent leakage. Threads must be the correct length and depth in order to insure strong, permanently watertight joints. If the dies are properly adjusted, the threading operation should stop when the end of the pipe is flush with, or projects one-half thread beyond, the face of the die. Pipes threaded in this manner should enter the fittings easily enough to run up three full threads by hand. Then a friction type wrench should be used to screw the threads up the remainder of the way.

When cutting threads by hand, lubricating the die during the cutting process is very important. Coolants such as lard, oil, or a soapy water solution will reduce the effort required and will improve the quality of the threads. When large sizes of pipe are threaded by machine, some means of cooling should always be provided. Dies, operating at a high temperature due to friction, have a tendency to dull and plug up with metal chips. In selecting an oil, it is well to remember that its function is to cool as well as to lubricate.

**Exercises (428):**

Select the correct statements by placing a checkmark (√) in the spaces provided.

____ 1. Copper and brass pipes are of softer and more ductile metal than iron or steel.

____ 2. A satisfactory tool used to cut brass pipe has two thin cutting wheels and one roller.

____ 3. Knife cutters are recommended for cutting pipes over 2 inches in diameter.

____ 4. A slight bevel, left after removing the burr, materially aids the flow of water through the pipe.

____ 5. Torn threads will always make watertight joints.

____ 6. A friction type wrench should be used to tighten threaded brass or copper pipe.

____ 7. When selecting a cutting oil, it is well to remember that its function is to cool as well as to lubricate.

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# Insulation and Winterization of Plumbing

BENEFITS DERIVED from the use of insulation go back thousands of years to when primitive man in tropical areas stripped bark from cork trees to use for the roof of his crude hut. We can surmise that primitive people observed that cork trees withstood the severe tropical heat and concluded that the bark would make excellent protection from the rays of the sun.

Sometimes the Air Force has buildings on military bases that are placed on standby status (unoccupied). As an Air Force plumber, it will be your job to winterize the plumbing systems in these buildings where below freezing temperatures occur. Therefore, you must know how to winterize these systems correctly to prevent damage to the plumbing systems and to insure that the buildings are readily available for use when they are needed again.

Plumbing systems in use will freeze when the temperature falls to 32° or less if they are not properly protected. This condition poses another problem for the plumber. In the event the plumbing in a building freezes, you will have to thaw it out by one of several methods. You must know each method thoroughly to prevent damage to the pipes during the thawing process.

This chapter provides information on the purpose of insulation, insulation materials, installation of insulation, maintenance of insulation, winterization of plumbing systems, thawing frozen pipes, electrical thawing equipment, and safety procedures that you should observe when using high-amperage thawing equipment.

## 4-1. Insulation of Pipes

Now that you know how to fabricate plumbing systems, let's find out why and how they are insulated.

Most people know the function of insulation as applied to electrical wiring. The layman knows that insulation on electrical wire is used to keep the current within the wire and to prevent it from contacting other objects. He also knows that refrigerators must be insulated to obtain satisfactory operating efficiency. So we can say that insulation acts as a barrier which hinders or prevents the passage of heat, moisture, or sound.

### 429. Identify the correct statements pertaining to the purpose of insulation.

**Purpose of Insulation.** The purpose of insulation is primarily to prevent heat passage from steam or hot water pipelines to the surrounding air, or from the surrounding air to cold water pipes. Thus, hot water lines are insulated with the idea of preventing the loss of heat from the hot water, whereas drinking water lines are insulated to prevent the addition of heat to the drinking water. Insulation will prevent the accumulation of moisture by condensation on the outside of cold pipes. An example of condensation is the formation of droplets of moisture on the outside of a glass of ice water on a warm day. The same thing will happen to the outside of a pipe containing cold water when the outside of the pipe is exposed to warm air. Insulation will also prevent water from freezing in a pipe, especially when the pipe runs outside a building or in a building without heat.

Insulation is also used on heating and air-conditioning ducts. There are two kinds of duct insulation, inside and outside. The outside insulation is used for the protection of heat loss, whereas the inside insulation is used for protection against noise and vibration from heating or air-conditioning equipment.

Insulation is also used for the purpose of subduing the noise made by the flow of water inside pipes, such as the flow of water from water closet discharges. This type of insulation is especially desirable where bathrooms are located directly above living rooms, and in high buildings where the water must fall great distances, especially where the water falls in the soil stacks and headers. Another great demand today for insulation is to protect refrigerated and chilled water lines used to cool electrical and motor-driven equipment.

**Exercises (429):**

Identify the correct statements by placing a C in the appropriate spaces.

____ 1. Hot water lines are insulated with the idea of preventing heat loss.

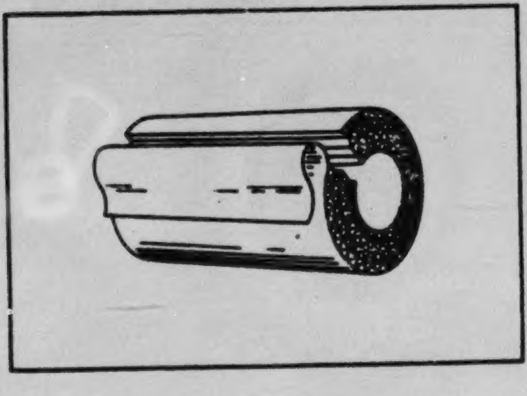

Figure 4-1. Air cell insulation.

____ 2. Drinking water lines are insulated to prevent the addition of heat to the drinking water.

____ 3. Insulation will not prevent the accumulation of moisture by condensation on the outside of cold water pipes.

____ 4. The primary purpose of insulation is to prevent heat passage from hot pipes to surrounding air or from surrounding air to cold water pipes.

____ 5. Inside insulation is used to protect against heat loss.

### 430. Match the appropriate types of insulation to the job.

**Insulation Materials.** Insulation is manufactured in two general types: (1) rigid preformed sections and (2) the blanket type.

*Rigid Preformed.* Rigid preformed sections are used on pipe runs and for the protection of other objects which they are designed to fit. Some of the rigid types of insulation that are on the market today are air cell, sponge felt paper, cork, woodfelt, flex rubber, Fiberglas, 85 percent magnesia, antisweat, and frostproof.

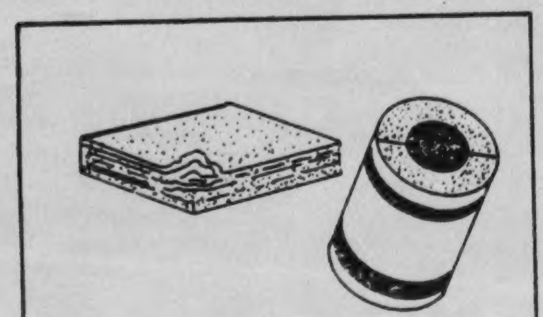

Figure 4-2. Sponge felt paper insulation.

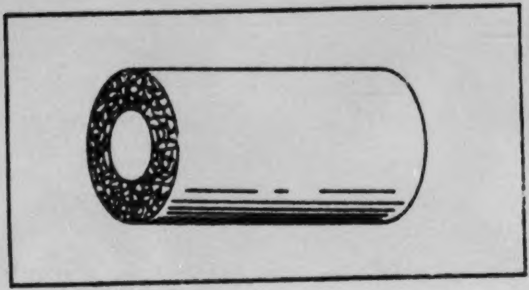

Figure 4-3. Molded cork pipe covering.

*a.* Air cell. Air cell pipe covering is made of fine quality asbestos paper. The covering is generally used to cover low-pressure steam and vapor lines. Air cell insulation is formed by layers of plain asbestos felt that is alternated with corrugated asbestos felt, with each lamination or ply approximately 1/4 inch thick. Air cell insulation is furnished in 3-foot lengths, unless otherwise specified, and is covered with a canvas jacket, as shown in figure 4-1.

*b.* Sponge felt paper. Sponge felt paper is composed of asbestos paper with a maximum amount of sponge evenly distributed within it, as shown in figure 4-2. It has approximately 37 to 43 laminations to the inch and is uniformly round, rigid, and closely constructed. Sponge felt paper is manufactured to fit most pipe sizes. It comes in 3-foot lengths and from 1 to 3 inches in thickness. Sponge felt paper can be purchased in blocks of straight and preformed shapes to be used on valves and fittings.

*c.* Cork pipe covering. Cork pipe covering is a granulated material that is processed from the bark of cork trees. When it comes to advantages, no other product can match all the benefits of molded cork covering. A piece of cork pipe covering is illustrated in figure 4-3. This pure, clean, granulated cork is compressed and molded to the exact size and shape, and finished with a coating of plastic asphalt. Cork pipe covering is an ideal covering for brine, ammonia, ice water, and all kinds of cold water lines. It has excellent insulating qualities over a wide low-temperature range. Cork pipe covering will not rot or support combustion, and is clean, sanitary, and odor-free. It is available in a wide variety of sizes and shapes that can be used on various sizes of pipes and fittings.

*d.* Woolfelt. Woolfelt is made of matted fibers of wool, wool and fur, or hair worked into a compact material by pressure rolling. It is used on cold water service and hot water return lines. Woolfelt preformed pipe covering is manufactured in thicknesses of 1/2 to 1 inch, with a canvas jacket, as shown in figure 4-4. It is manufactured in 3-foot lengths to accommodate straight runs of pipe.

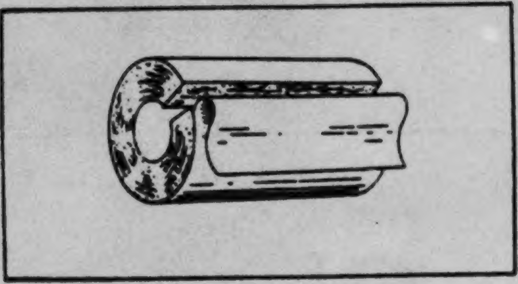

Figure 4-4. Woolfelt pipe covering.

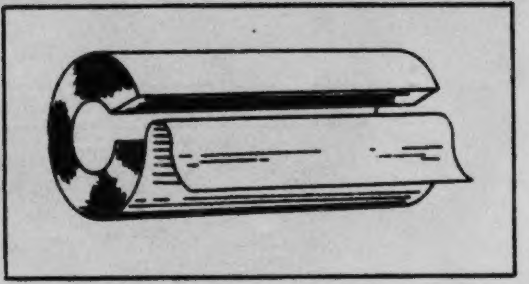

Figure 4-6. Fiberglas insulation.

*e.* Flex rubber. Flex rubber insulation, shown in figure 4-5, is a tough, flexible rubber material constructed of millions of uniform closed cells. It has good insulating qualities, good cementing qualities, excellent weather aging qualities, and is ideal for the prevention of sweating of cold water lines. In addition, it is water and flame resistant. Flex rubber insulation is recommended for covering tubing used in refrigeration and cold water lines in homes as well as in industrial plants and commercial buildings. This rubber insulating material comes in random lengths with a wall thickness size of 3/8 to 3/4 inch. It is made to fit pipe sizes up to 4 inches.

*f.* Fiberglas. Fiberglas pipe insulation, shown in figure 4-6, is composed of very fine glass fibers bound and formed together by an inactive resin type mixture. It is formed into a flexible hollow cylinder, and slit along its length to permit application to pipes or tubing. Fiberglas insulation is also shaped to fit small boilers and hot water heaters. It is furnished in 3-foot lengths with or without jackets. The insulation comes in thicknesses from 1/2 to 2 inches and will accommodate pipes from 1/2 to 30 inches. Fiberglas insulation has long life; it will not shrink, swell, rot, or burn. It is easily applied, light in weight, space saving, and has excellent insulating qualities.

*g.* Magnesia insulation, shown in figure 4-7, is composed of approximately 85 percent pure carbonate of magnesia and long threadlike asbestos fibers. This insulation is manufactured by a scientific process under which the magnesium carbonate is transformed into an expanded, light, bonded material. This process gives it maximum strength and uniformity, and causes it to be light in weight, which makes it the best insulating material. Magnesia insulation is an excellent material for high-temperature (550° F.) and high-pressure steam lines. It is covered with a canvas jacket and may be used on pipes up to and including 30 inches in diameter. The efficiency of magnesia insulation is approximately 90 percent when it is installed on bare metal parts. Magnesia insulation can be furnished with a heavier-than-standard canvas waterproof jacket if it is to be exposed to outside conditions or placed in underground work. Magnesia insulation is used in standard and double standard thickness material. The standard thickness used for 1/2-inch pipe is 7/8 inch thick, and the double standard thickness is 1 7/8 inches thick. The difference in thickness of the standard and double standard will remain about the same for all pipes up to 30 inches in diameter. The double standard thickness is used more extensively on high-temperature lines. Magnesia pipe covering is made in sections 3 feet long with collars for covering the end seams.

*h.* Antisweat. Antisweat insulation, shown in figure 4-8, is designed for use on cold water pipes. It keeps the water colder in the pipes than most types of insulation, and if properly installed, it prevents

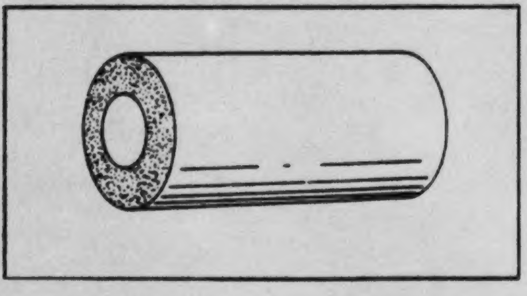

Figure 4-5. Flex rubber insulation.

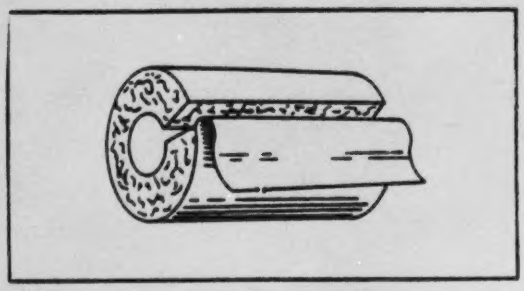

Figure 4-7. Magnesia insulation.

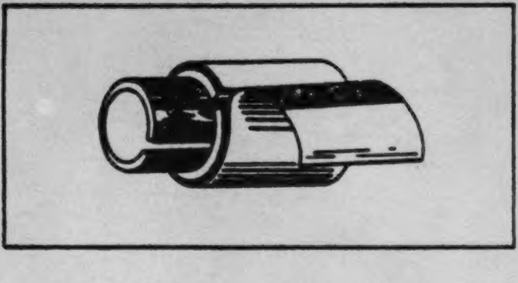

Figure 4-8. Antisweat insulation.

condensation or sweating of the pipes. The outstanding feature of antisweat insulation is its construction. It is composed of an inner layer of asphalt-saturated asbestos paper, a 1/2-inch layer of woolfelt, two layers of asphalt-saturated asbestos felt, another 1/2-inch layer of pure woolfelt, and an outer layer of deadening felts combined with asphalt-saturated felts. The outer layer has a flap about 3 inches long which extends beyond the joint to help make a perfect seal. A canvas jacket is placed around each 3-foot length to protect the outer felt covering.

*i.* Frostproof. Frostproof insulation, shown in figure 4-9, is manufactured to be used on cold water service lines that pass through unheated areas and those exposed to outside weather conditions. Frostproof insulation is generally constructed of five layers of felt. These layers include three of pure woolfelt and two of asphalt-saturated asbestos felt. Frostproof insulation comes in 3-foot lengths, and is $1\frac{1}{4}$ inches thick with a canvas cover.

*Blanket type.* The blanket type insulation is manufactured in strips, sheets, and blocks. It is used to wrap around objects that are irregular in shape and for large, flat areas. Blanket type insulation is designed to insulate against heat loss and protect against fire. This type of insulation is used on boilers, furnaces, tanks, drums, driers, ovens, flanges, and valves. It comes in asbestos paper rolls, asbestos cardboard sheets, woolfelt and hairfelt rolls, asbestos cement blocks, air cell rolls, aluminum foil rolls, irregular preformed covering, and asbestos powder.

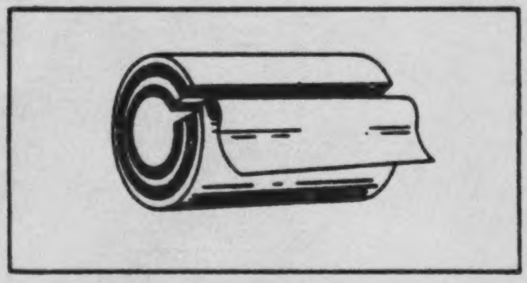

Figure 4-9. Frostproof insulation.

Blanket insulation comes in different widths and thicknesses, depending on the type of equipment to be insulated. It resists vermin, rodents, and acid, and it is fireproof. The asbestos type will stand more heat than the other types. Therefore, you should use it on high-temperature equipment and where protection is required against an open flame.

**Exercises (430):**

Match the insulation in column A with the statement in column B by placing the appropriate letter in the blank space provided.

| | *Column A* | *Column B* |
|---|---|---|
| ___ 1. | Used to cover low-pressure steam lines. | a. Cork insulation |
| ___ 2. | Used to insulate brine and ammonia lines. | b. Flex rubber insulation |
| ___ 3. | Used to insulate refrigeration and cold water lines. | c. Blanket insulation |
| ___ 4. | Used on high-pressure steam lines. | d. Air cell insulation |
| ___ 5. | Used to insulate irregular objects and flat areas. | e. Magnesia insulation |

## 431. Choose correct statements relating to the installation of insulation.

**Installation of Insulation.** When insulation is to be installed on pipes, radiators, tanks, or boilers, the plumber should understand the procedures well enough to do the job quickly and efficiently. He should also know the maintenance that is required to get the maximum benefit from the equipment insulated.

*Installing pipe covering.* Pipe coverings, illustrated in figures 4-3 through 4-11, indicate some of the types of covering available to the plumber today. These coverings are easily installed, because each section is split in half and has a canvas cover with a flap for quick sealing. Joint collars are furnished to cover joint seams on insulation exposed to outside conditions.

Cheesecloth is used on some types of insulation instead of canvas. When cheesecloth is installed, a paste must be used to glue it in place. Enough cheesecloth should extend over the end of each preformed, 3-foot section to cover the joints. If the cheesecloth is smoothed properly after the paste is applied, it makes a good uniform installation. After the insulation is properly installed, metal straps should be used to hold the insulation firmly in place, as shown in figure 4-10. These metal straps should be at least 3/4 inch wide, and the maximum distance they should be spaced apart is 18 inches. Where the insulation needs to be kept clean, it may be necessary to paint it with a special type of white enamel paint. This glossy type of finish will make it easier to keep the insulation clean.

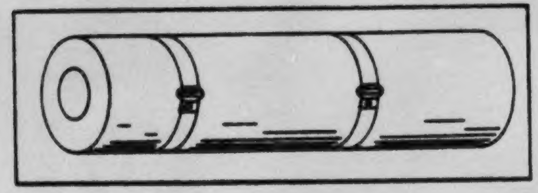

Figure 4-10. Pipe insulation showing metal straps.

Flex rubber insulation can be installed on pipes and tubing by slipping the insulation over the piping when it is being assembled or by slitting the rubber lengthwise, as shown in figure 4-11, and sealing it together with cement. Before flex rubber insulation is installed on iron or galvanized pipes, the pipes should be painted with an asphalt base primer to prevent corrosion caused by condensation.

*Installing covering on valves and fittings.* Valves and fittings are covered with wool, felt, magnesia cement, or mineral wool cement of the same thickness as the pipe covering. These materials are molded into shape to conform with the rest of the insulation. If magnesia or mineral wool cement insulation is used, the insulation is covered with cheesecloth to help bind and hold it in place.

*Installing covering on boilers and tanks.* If boilers and storage tanks are unjacketed, they should be covered with an approved insulation. Only insulation which has been approved by the Air Force can be used. Some of the approved types of insulation for tanks and boilers are magnesia, mineral wool, calcium silicate, cellular glass, or some other approved mineral insulation at least 2 inches thick.

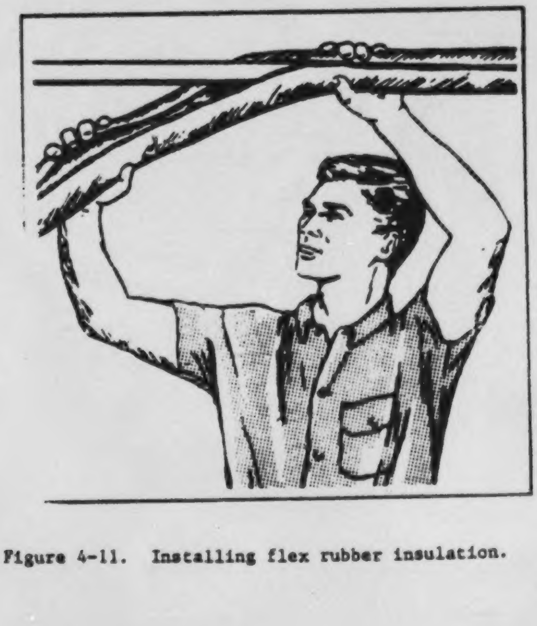

Figure 4-11. Installing flex rubber insulation.

Insulation may be either of the block or blanket type and must be securely wired in placed in an approved manner. Insulation applied to the outside of a boiler or storage tank should be applied over $1^1/_2$-inch wire mesh which is held away from the metal surface by metal spacers that provide an air space of at least 1 inch. When blanket or block type material is used, the joints in the insulation should be filled with magnesia, mineral wool, or some other suitable cement. The surface of the insulation should be covered with a thin layer of hard-finished cement, troweled smooth, and reinforced with $1^1/_2$-inch wire mesh.

**Exercises (431):**

Choose the correct statements by placing a C in the appropriate spaces.

____ 1. When cheesecloth is installed, a paste must be used to glue it in place.

____ 2. One-half-inch metal straps should be placed every 24 inches on insulation.

____ 3. Before flex rubber insulation is installed on iron or galvanized pipes, the pipes should be painted with an asphalt base primer.

____ 4. Magnesia, mineral wool, calcium silicate, and cellular glass are approved insulations for insulating boilers and tanks.

____ 5. Insulation applied to the outside of a boiler or storage tank should be applied over $1^1/_2$-inch wire mesh.

____ 6. The joints on blanket or block insulation should be taped with masking tape.

**432. Provide brief answers to questions pertaining to maintenance of insulation.**

**Maintenance of Insulation.** Very little maintenance is required on insulation if it is properly installed. Insulation exposed to weather and subjected to damage from sharp objects will require frequent inspections and some maintenance. If the canvas cover gets torn or punctured, it should be patched with another piece of canvas. The paste for installing a patch on insulation that is used inside buildings should not be used to apply a patch on insulation exposed to outside weather conditions. Use a weatherproof paste for outside insulating jobs.

When a leak is detected in a pipe system covered with insulation, a considerable amount of work is required to make the repair. Enough of the insulation must be removed to uncover the damaged pipe, and the pipe must be removed and replaced. When the pipe has been reinstalled, usually with a union the pipe and union must be insulated with the same type of insulation as that used for the rest of the system.

During an inspection you may find loose straps or loose insulation material around valves and fittings. The straps should be retightened, and the loose insulating material should be replaced or pasted down. Proper installation of insulation and frequent inspections will minimize maintenance problems and prolong the service life of the insulation.

**Exercises (432):**

1. What type paste should be used to patch insulation that is exposed to weather?

2. What type of insulation should be installed to replace insulation that has been damaged due to a leaking pipe?

3. What should be done when loose insulation straps are discovered during an inspection?

## 4-2. Winterization of Plumbing Systems

Sometimes the Air Force has buildings that are vacant for one reason or another. In locations where freezing temperatures occur, it will be your job to winterize the plumbing system to prevent damage to the piping and fixtures. In cases where a building's plumbing system has frozen, you will have to thaw out the frozen system.

### 433. Identify the true statements pertaining to thawing frozen pipes.

**Thawing Frozen Pipes.** Pipes inside a building freeze when the building is left unheated or when the lines are located in unheated spaces. Measures to prevent pipes from freezing in heated buildings should be taken when the lines are installed. If freezing does occur, the best method of thawing the frozen section depends upon its location and accessibility. The only way to thaw a frozen pipe is to apply heat, but there are many ways of applying the heat.

Heat applied to a frozen pipe must be applied first at either end or both ends of the section which is frozen. If it is applied at or near the middle of the frozen section, the expansion of the heated water against the remaining ice may burst the pipe. When you thaw a water supply pipe, start at the supply end and work toward a faucet. The faucet should be kept open to relieve the pressure on the section of the pipe being thawed. When you thaw a waste or drain pipe, work from the sewer end toward the fixture.

*Thawing pipes with boiling water.* Probably the most common and the least dangerous method of thawing frozen pipes is with boiling water. It is considered an effective means, but safety precautions must be adhered to when you handle boiling water, because if you splash it on yourself or your coworkers, severe burns may result. There are several ways in which boiling water may be applied to thaw pipes. Probably the simplest way, if the pipe is exposed, is to wrap it with rags or burlap to obtain a suitable thickness. Then keep the wrapping saturated with boiling water. This method is shown in figure 4-12.

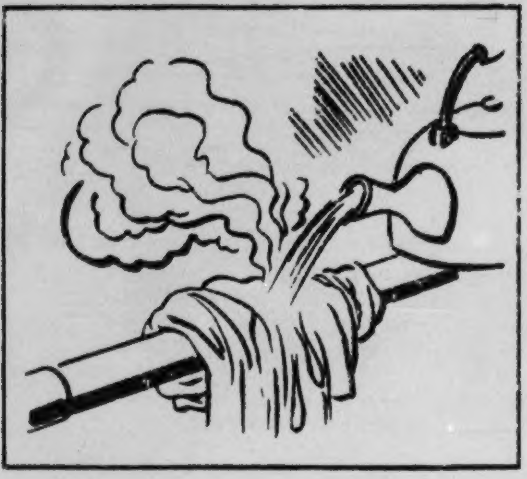

Figure 4-12. Hot water applied to the outside of a frozen pipe.

Frozen water supply pipes that are located where heat cannot be readily applied to the outside of the pipes are often thawed by pouring hot water through a

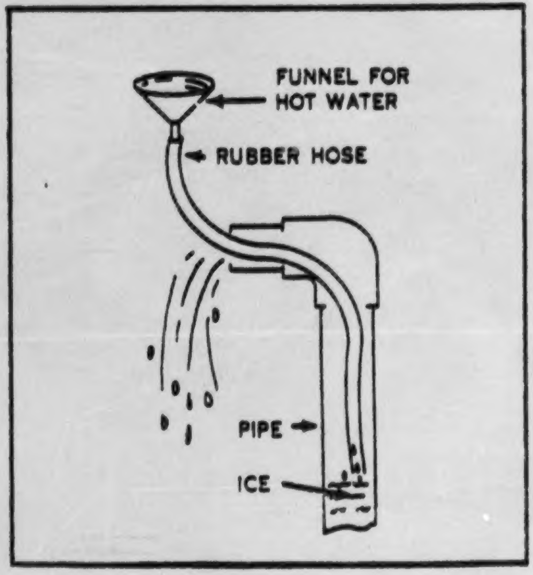

Figure 4-13. Hot water applied to the inside of a frozen pipe.

rubber hose inserted inside the pipe, as shown in figure 4-13. To use this method, it is necessary to close the service valve and then remove a faucet, valve, or fitting to open the exposed end of the pipe. The rubber hose is pushed into the pipe as far as possible and a funnel is inserted in the hose. Hold the funnel above the end of the pipe and pour boiling water into it against the ice in the pipe. As the water flows into the pipe through the hose, the surplus will escape through the opening where the hose is inserted into the pipe. Usually this water must be caught in a pail or by some other means to prevent damage to, or flooding of, the structure. The end of a flexible rubber hose may be worked around one elbow by twisting and pushing it, but to get the hose farther into the pipe may require the removal of some of the fittings and pipe lengths. Turn on the service valve whenever you think the line is thawed. As soon as water flows from the supply, the hose may be pulled out. Keep the service valve open enough to maintain a small flow of water while you reassemble the pipe connections. If the water flow is stopped immediately, the pipe is likely to freeze again before it is cleared of ice.

*Thawing pipes with chemicals.* Chemical cleaners, such as sodium hydroxide used to clear clogged drain pipes, generate a great deal of heat when they are mixed with water. These chemicals will often prove effective in thawing the ice in a frozen drain or waste line. They are poured into the pipe in the same manner as though the pipe were being cleaned. However, larger quantities of these chemicals are required to thaw a frozen pipe than are required to clear a clogged drain pipe.

*Thawing pipes with a torch.* A common method of thawing water pipes, though dangerous because of the fire risk it involves, is to play the flame of a torch along the frozen part of the pipe. To thaw a pipe with a torch, open the faucets in the line and apply heat at one end of the pipe. Work along the entire length. Heat the pipe until the water runs from the faucet. Allow the water to run for some time so that the line does not freeze again when the water is turned off. When thawing pipes with a torch, you must take every precaution to avoid setting the building on fire.

*Thawing pipes with building heat.* Where the freezing is due to the failure of the heating system, the easiest method of thawing pipes is to repair the heating plant first. Then, maintain a high temperature in the building until the frozen pipes are thawed. If freezing has broken a pipe, as soon as the pipes are thawed, shut off the water at the meter or at the nearest fixture riser below the ruptured section. Then repair the pipe which has been cracked.

*Thawing pipes with electricity.* Thawing frozen water pipes with low-voltage electricity is by far the best method. It is not only convenient but it is faster, safer, and cheaper. This method works satisfactorily with both steel and copper pipe and copper tubing. It thaws the ice in pipes regardless of their location, including those buried in the ground or concealed in walls.

Whenever an electric current is passed through a wire, pipe, or other conductor, resistance is encountered. This resistance creates heat. For example, you have probably noticed how an electric cord that is overloaded becomes warm. This is caused by resistance in the wire which generated heat in the cord.

Steel is a rather poor conductor of electricity. Considerable resistance is encountered when attempting to pass an electrical current through it. In pipe thawing, enough current must be used to cause heating of the pipe.

The amperes and time needed to thaw steel pipe of different sizes is shown in figure 4-14. For any given

| PIPE SIZE | | | | | | APPROXIMATE TIME REQUIRED |
|---|---|---|---|---|---|---|
| 1/2 inch | 3/4 inch | 1 inch | 1 1/4 inch | 1 1/2 inch | 2 inch | |
| 200 amps | 270 amps | 400 amps | | | | 3 - 4 Minutes |
| 150 | 200 | 300 | 400 amps | | | 6 - 8 Minutes |
| 125 | 170 | 250 | 340 | 400 amps | | 8 - 12 Minutes |
| 100 | 135 | 200 | 270 | 320 | 440 amps | 12 - 16 Minutes |
| 75 | 100 | 150 | 200 | 240 | 330 | 25 - 39 Minutes |
| 50 | 67 | 100 | 135 | 160 | 220 | 1 Hour |

Figure 4-14. Chart showing amperes and time required to thaw steel pipe.

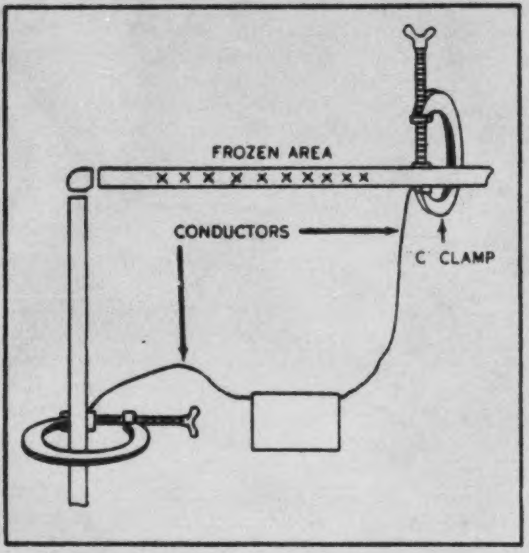

Figure 4-15. Method of connecting conductors to a pipe.

heating rate, the current in amperes is in proportion to the weight of the steel pipe.

Copper pipe requires more current than steel pipe for the same amount of thawing time because it is a better conductor of electricity. For 1/2-inch copper pipe, add 10 percent more current to the values shown in figure 4-14 than for steel pipe. For 3/4-inch copper pipe, add 25 percent more current.

The amount of current, either ac or dc, transmitted by a pipe varies with its length. The shorter the pipe, the greater the current flow for a given voltage. As the length of the pipe increases, the flow of current decreases. When the current (amperes) is doubled, the heating rate is four times as fast; and when the current is tripled, heating is nine times as fast.

When thawing any type of pipe with electrical equipment, it is a good practice to first isolate the frozen section of pipe. This is easily done inside a building by back tracing the pipes. If all the water outlets in the house fail to operate, usually the service line from the curb box to the building is frozen.

Good electrical connections are necessary when thawing pipe with electrical equipment. The point where the cables are attached to the pipe must be thoroughly cleaned. This is easily accomplished by rubbing the pipe with coarse emery cloth. Make sure the connections are tight to prevent arcing and burning a hole in the pipe. Either special pipe-thawing clamps or ordinary C-clamps are excellent for connecting the cables to the pipes (see fig. 4-15). Current used to thaw pipes may be produced by either an electrical transformer or an electrical generator. Figure 4-16, shows a transformer used for thawing pipes.

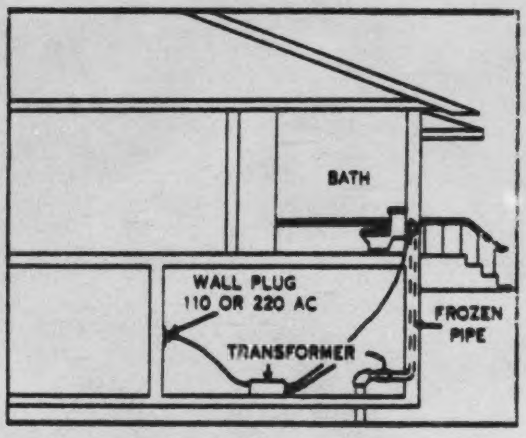

Figure 4-16. Thawing a water supply pipe with a transformer.

The cables carrying the current from the thawing unit should be connected at the nearest convenient point in the piping system that will place the frozen section of pipe in the electrical circuit, as shown in figure 4-15. For thawing mains, it is usually possible to make connections to fire plugs, curb service cocks, etc. House service pipes are usually thawed by connecting one cable to an exposed pipe in a room and the other to the curb service cock. In other cases, the second cable may be connected to an exposed pipe in an adjoining building. Many cases have been known where two or more service pipes have been thawed simultaneously by locating the cable connections to place the systems in the same circuit.

A point to remember when thawing frozen water pipes with electrical equipment is to leave a faucet open. This will permit the warm water from the unfrozen parts of the pipe to flow past the ice as soon as a thin film next to the pipe has melted. This flow of water, plus the heat from the current, will thaw the rest of the ice.

*Electrical thawing equipment.* The electrical thawing equipment used for average household plumbing is of the transformer type. It is designed to operate on either 110 or 220 volts alternating current, which is found in most barracks, mess halls, and residential buildings. This type of thawing equipment gives excellent results on short lengths of pipe up to 1½ inches in diameter. A transformer unit set up to thaw a water supply pipe within a wall that serves a water closet is shown in figure 4-16. The transformer leads are attached to the pipe so that the frozen section of the pipe is within the circuit. After the leads are properly connected to the pipe, the current is turned on and adjusted by turning the rheostat to the desired voltage.

A gas-engine-driven welder of at least 250 amperes capacity is better than the transformer unit for thawing larger and longer pipe runs. It will supply the higher current required for this purpose and can be used

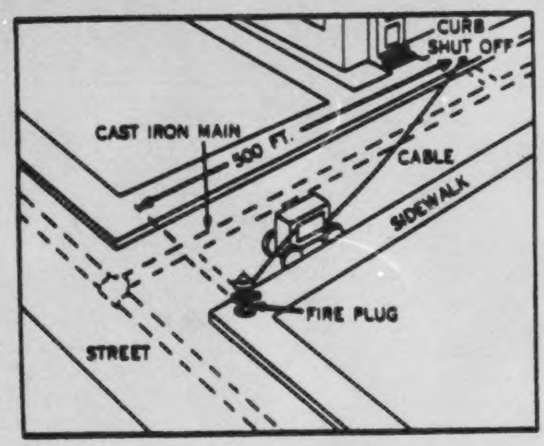

Figure 4-17. Engine-driven welder connected to thaw a street supply main.

where electrical power is not readily available, since it operates on gasoline. Since a welder can be used for welding as well as for pipe thawing, it is useful the year round. An engine-driven electrical welder set up for thawing a street supply main is shown in figure 4-17. As you can see in the illustration, one lead is connected to the curb box and the other lead is connected to the fire plug. Usually the gas-engine-driven welder is operated by the welder, but the plumber tells him the value of the current needed to thaw the specific pipe.

Cables from the generator of the engine-driven welder should be kept as short as possible and of adequate size to handle the current involved. The recommended cable sizes for various distances are shown in figure 4-18. Note that the cable sizes become progressively larger with increased cable lengths and increased current flows. When using direct current, the cables should never be coiled, because the induced magnetism will cause a reduction in current output.

Some safety precautions that you should observe when you use high-amperage thawing equipment are as follows:

- Don't touch any connections while the machine is in operation.
- Watch the meters very closely. To avoid damage to the generator, operate the generator at about 75 percent rated amperage.
- Keep the connections tight. Loose connections get hot and reduce current flow.
- Connect the conductors as close to the frozen area as possible. A small empty pipe in the circuit may get very hot before a large pipe will thaw. This condition could melt a soldered joint in copper pipes or set fire to combustible materials that are nearby.
- If the electrical wiring in a building is grounded in two places, a parallel low-voltage circuit may be established through the grounded neutral conductor. If this happens, the wiring may get hot and start a fire in the building. Disconnect the ground at one end of the electric wiring system while you are thawing pipes.

**Exercises (433):**

Identify the true statements by placing a T in the appropriate spaces.

____ 1. To thaw a frozen water pipe, you should start at the supply end and work toward a faucet.

| | DISTANCE IN FEET FROM WELDING MACHINE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AMPS | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 | 300 | 350 | 400 |
| 100 | 2 | 2 | 2 | 2 | 1 | 1/0 | 1/0 | 2/0 | 2/0 | 3/0 | 4/0 | 4/0 |
| 150 | 2 | 2 | 1 | 1/0 | 2/0 | 3/0 | 3/0 | 4/0 | 4/0 | 4/0 | 2-2/0 | 2-3/0 |
| 200 | 2 | 1 | 1/0 | 2/0 | 3/0 | 4/0 | 4/0 | 4/0 | 2-2/0 | 2-3/0 | 2-3/0 | 2-4/0 |
| 250 | 2 | 1/0 | 2/0 | 3/0 | 4/0 | 4/0 | 2-2/0 | 2-2/0 | 2-3/0 | 2-3/0 | | |
| 300 | 1 | 2/0 | 3/0 | 4/0 | 4/0 | 2-2/0 | 2-3/0 | 2-3/0 | 2-4/0 | | | |
| 350 | 1/0 | 2/0 | 4/0 | 4/0 | 2-2/0 | 2-3/0 | 2-3/0 | | | | | |
| 400 | 1/0 | 3/0 | 4/0 | 2-2/0 | 2-3/0 | 2-3/0 | | | | | | |

Figure 4-18. Chart showing the recommended cable sizes for an engine-driven welder.

____ 2. It is not necessary to close the service valve when using the boiling water, funnel, and rubber hose method to thaw frozen pipes.

____ 3. Sodium hydroxide may be used to thaw frozen drain pipes.

____ 4. The best method of thawing frozen pipes is low-voltage electricity.

____ 5. Steel pipe requires more current than copper pipe for thawing.

____ 6. A point to remember when thawing frozen water pipes with electrical equipment is to leave a faucet open.

____ 7. The electric thawing equipment used for average household plumbing is the transformer type.

### 434. Provide brief answers to questions pertaining to winterizing plumbing systems.

**Winterizing Plumbing Systems.** Plumbing systems that are exposed to freezing temperatures must be protected to prevent bursting of the pipes and equipment. When the heating system is cut off, the water in the pipes and traps must be drained to prevent damage to the plumbing system. Even though the pipes are covered with insulation and the fixtures are protected in a building, the water in them will freeze if the temperature goes low enough; therefore, it is best to winterize the plumbing system to protect it from damage.

*Draining the water supply system.* To drain the water supply system, the service valve where the service pipe enters the building must be closed. This valve may have its own handle or may require the use of a wrench. Many service and shutoff valves have a drain hole through which water will drain from the building pipes when the valve is closed. With the service or shutoff valve closed, the highest faucet in the system should be opened to admit air, and the lowest fixture faucet should be opened to allow the escape of water. After the water ceases to flow from the lower faucet, the remainder escapes through the drain hole in the shutoff valve.

For complete drainage, the water closet tanks must be emptied. These tanks are emptied by flushing, and the water remaining below the outlets is removed by sopping it up with a cloth or sponge.

Hot water tanks and water heaters should be emptied only after the fires are out. These tanks have a drain valve near the bottom, and a union in the line to the heater is opened to allow air to enter while the water flows out of the tank. For tanks that do not have these cocks, you will have to admit air into them by unscrewing a fitting above the tank.

Water tanks are often drained by attaching a garden hose to the drain valve of the tank and draining the water to the outside of the building.

*Draining the waste system.* The traps must be drained of waste water to prevent them from freezing. However, these traps must be refilled with some antifreeze solution to keep sewer gas from entering the building. Antifreeze used in automobile radiators for a given outdoor temperature is suitable for filling traps when the same temperature is to be guarded against. Any of the glycol antifreeze preparations are highly effective, as is a mixture of glycerin and water. Alcohol and water or calcium chloride and water may also be used. An alcohol mixture should be used for temporary protection or replenished frequently, because alcohol will evaporate after a short time and leave the traps unprotected. For this reason, it is better to use glycerin or glycol, since neither evaporates when in solution under normal conditions.

Traps fitted with cleanout plugs are easily drained by removing the plug. Traps without cleanout plugs may be emptied with a suction pump, by using a small hose attached to a bulb syringe, or by siphoning the water with a small rubber hose. To siphon a trap, the hose is filled with water and both ends are pinched shut while the hose is taken to the trap. One end must be inserted into the trap as soon as it is released before the water runs out of the tubing. The other end is held at a point as far as possible below the water level in the trap and released, whereupon water from the trap will be drawn out through the tubing.

Drainage lines should be buried below the frost level to prevent them from freezing. Where this is impossible, the lines should be insulated and the insulation wrapped in a moistureproof covering.

**Exercises (434):**

1. What faucet should be opened after the service valve has been closed to admit air to the system?

2. How are water closet tanks emptied for winterizing?

3. What fitting is opened to allow air to flow into the water heater when draining?

4. What should the trap be refilled with after the water has been removed?

5. How can traps without cleanout plugs be emptied?

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CHAPTER 5

# Water Heaters, Dishwashers, Steam Kettles, Sinks, and Auxiliary Plumbing Equipment

THERE WAS A TIME when hot running water in a dwelling was considered a luxury, and very few people, even those who were considered well-to-do, were able to afford this convenience. Sanitation standards of today, however, require the installation of some type of hot water system in the humblest of dwellings. Hot water is also needed for industrial purposes. Think of your need for hot water each day. Your shave and shower, the dishes from each meal, and your laundry all need and use hot water.

Dishwashers and steam kettles are labor-saving machines used in Air Force and commercial kitchens. Both machines do their jobs quickly and efficiently, and are sanitary in performing their specific jobs. Because of their widespread usage, it is advisable that you acquaint yourself with these machines and learn how to install and maintain them.

When you install kitchen equipment such as kitchen sinks, slop sinks, scullery sinks, two-compartment sinks, and grease traps, you should inspect each unit before you install it to see that it is in good operating condition. If the equipment is new, procure the manufacturer's rough-in specifications and follow the suggested installation procedures. However, if the equipment is used and you are installing it in a new location, you will have to determine how to install it and the materials that are required to make the installation. It will be up to you to do the job.

This chapter covers the types, installation, starting, and maintenance of water heaters. It also covers construction, installation, operation, and maintenance of dishwashers, steam kettles, and sterilizers. The installation and maintenance of kitchen slop and scullery sinks are discussed. The chapter will also cover the construction, installation, and maintenance of laundry tubs, grease traps, laundry machinery, and auxiliary plumbing equipment.

## 5-1. Water Heaters

When you install water heaters, you should check

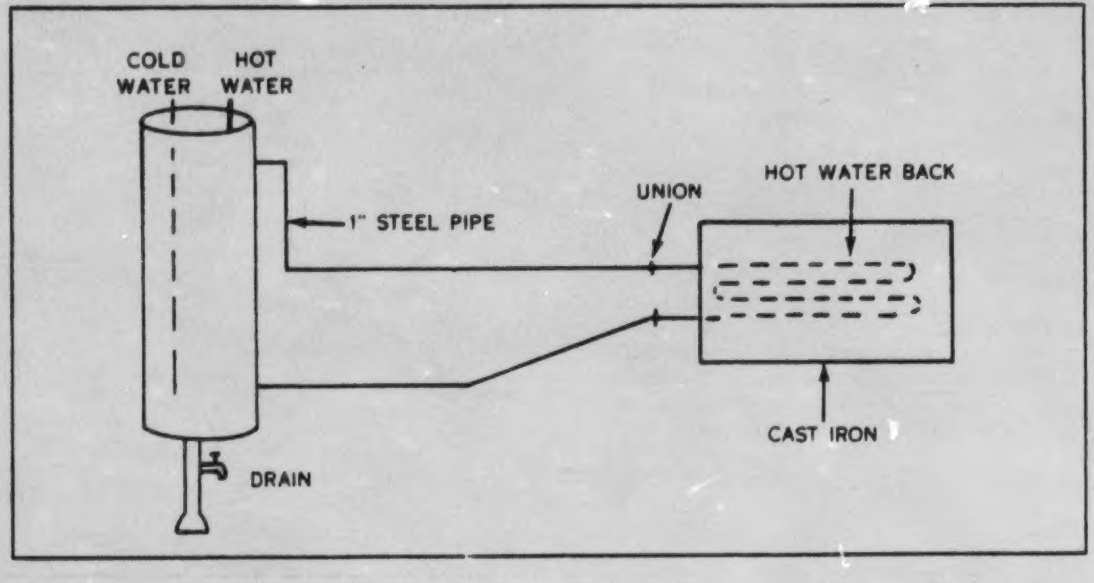

Figure 5-1. Water-back hot water system.

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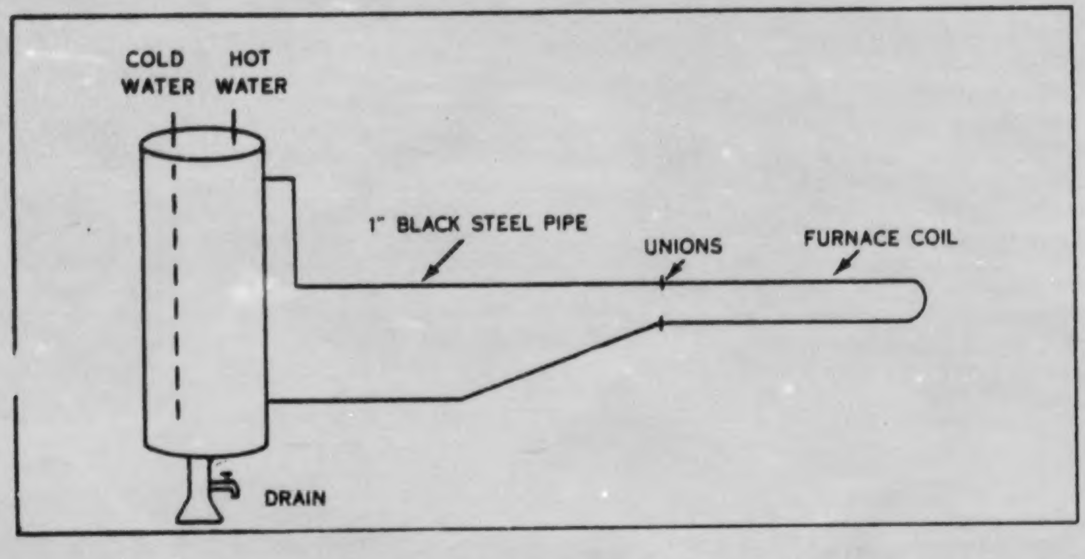

Figure 5-2. Furnace coil hot water system.

the units beforehand to determine the equipment that is needed to make the installation. Do not start to install the unit until all the equipment that is required is available. Be sure to procure the rough-in specifications for the equipment that you are going to install.

Water systems that are installed incorrectly will cause you many maintenance problems. Many installations of the past and some of those installed today are giving only a limited amount of satisfactory results. This condition is due largely to a lack of knowledge on the plumber's part of the principles involved.

**435. Mark the correct statements about various types of water heaters.**

**Types of Water Heaters.** Water heaters can be grouped in three categories: (1) range boilers, (2) gas-fired instantaneous heaters, and (3) storage type gas and electric heaters. The more common and standard types of heating devices are the water-back, furnace coil, coal, auxiliary gas, instantaneous heater, and underwater line heater. Each of these heating devices must have a water storage tank. The tank can be a part of the unit or an auxiliary tank.

*Water-back heater.* The water-back water-heating system, shown in figure 5-1, was probably the first method used in heating water for domestic use. The cast-iron heating unit was installed on one side of the firebox of a range that was used for both heating and cooking. The unit had waterways or channels for the circulation of the water. The water-back was very

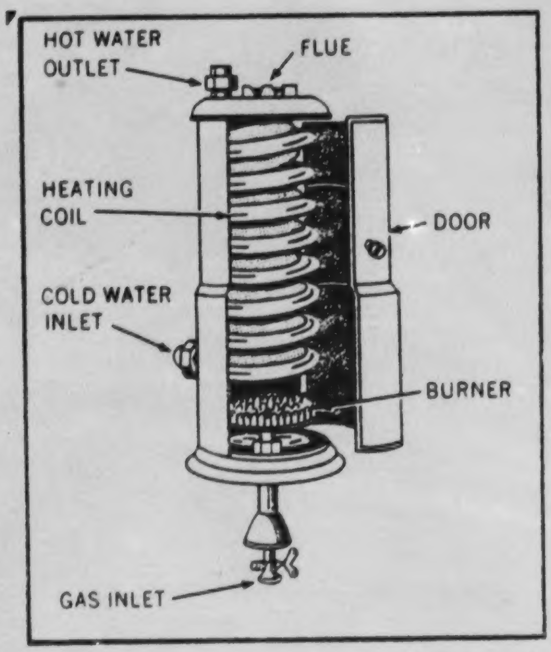

Figure 5-3. Auxiliary gas heater.

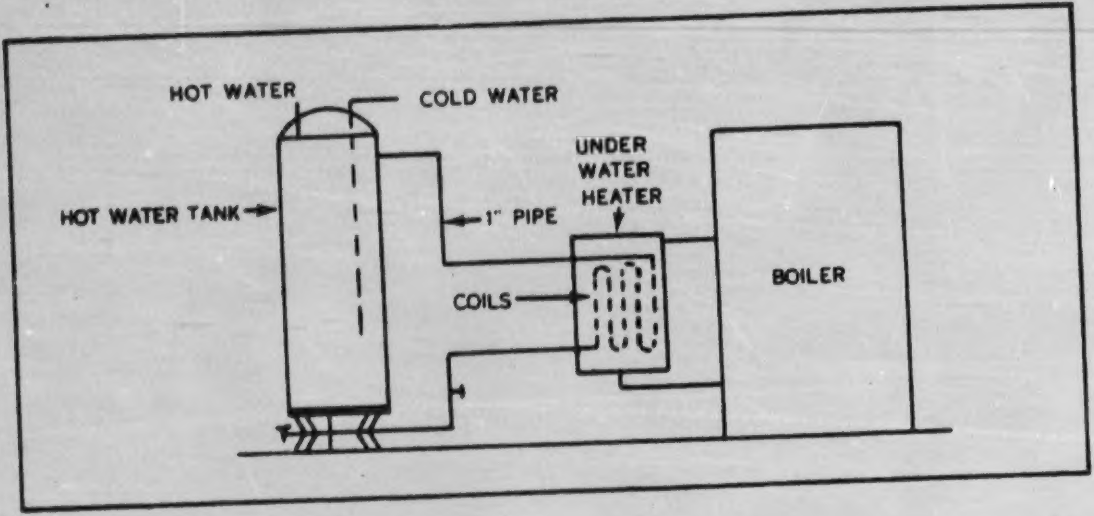
HOT WATER
COLD WATER
UNDER WATER HEATER
HOT WATER TANK
1" PIPE
COILS
BOILER

Figure 5-4. Underwater heater system.

efficient but has become obsolete because newer and more modern heating devices are used.

*Furnace coil heater.* Most furnace coils are constructed of black steel pipe, usually 1 inch in diameter, formed in the shape of a "U," as shown in figure 5-2. This is the most commonly installed heating device. This does not mean that it is the most efficient type of heating unit. The furnace coils are placed in the firebox of a heating furnace directly above the live fire. The water circulates through the coils, which heat the water as it is used from the faucet. This type of heating device is used more commonly in the Northern States where homes are equipped with coal-burning basement type heating furnaces.

*Auxiliary gas heater.* The auxiliary gas heater, shown in figure 5-3, is often used in conjunction with another heating unit. This unit may be installed with the furnace coil type heating unit to supply hot water during the time the furnace is on standby. The auxiliary gas heater is constructed of cast iron into which is fitted a 3/4-inch copper coil. The heat is supplied by a gas burner located at the bottom of the coil, as shown in figure 5-3. This heater must be equipped with a vent flue to carry away the dangerous and objectionable gases and odors. The heater is connected to a hot water storage tank similar to the one indicated in figures 5-1 and 5-2.

*Instantaneous water heater.* The instantaneous water heater is not as popular as the auxiliary gas heater because of its high cost of operation. This heater is used mostly in installations where plenty of hot water is required at short intervals. The instantaneous water heater consists of a cast-iron body in which many feet of copper coils are installed. The coils in the heater are heated by a gas burner which is located at the bottom of the coils. This heater is equipped with water valves which open and close as the water is drawn from the

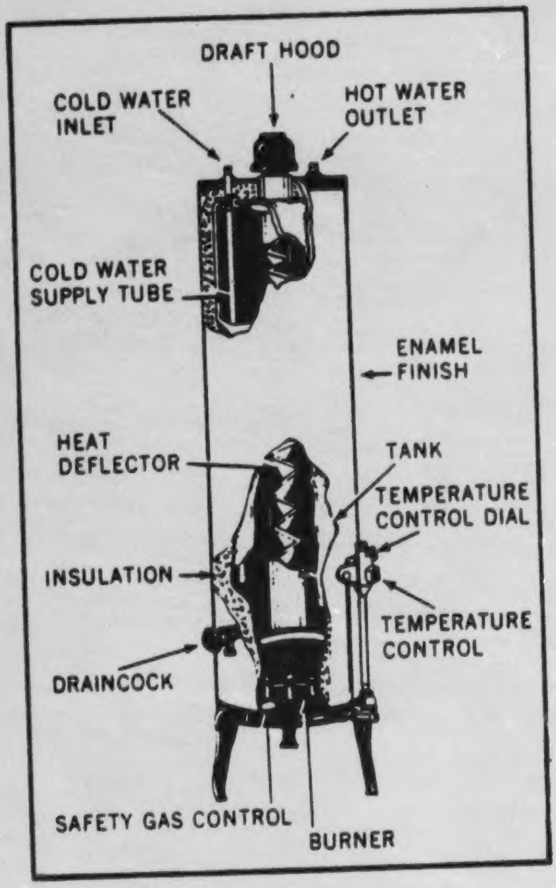
DRAFT HOOD
COLD WATER INLET
HOT WATER OUTLET
COLD WATER SUPPLY TUBE
ENAMEL FINISH
HEAT DEFLECTOR
TANK
TEMPERATURE CONTROL DIAL
INSULATION
TEMPERATURE CONTROL
DRAINCOCK
SAFETY GAS CONTROL
BURNER

Figure 5-5. Typical construction of a gas water heater.

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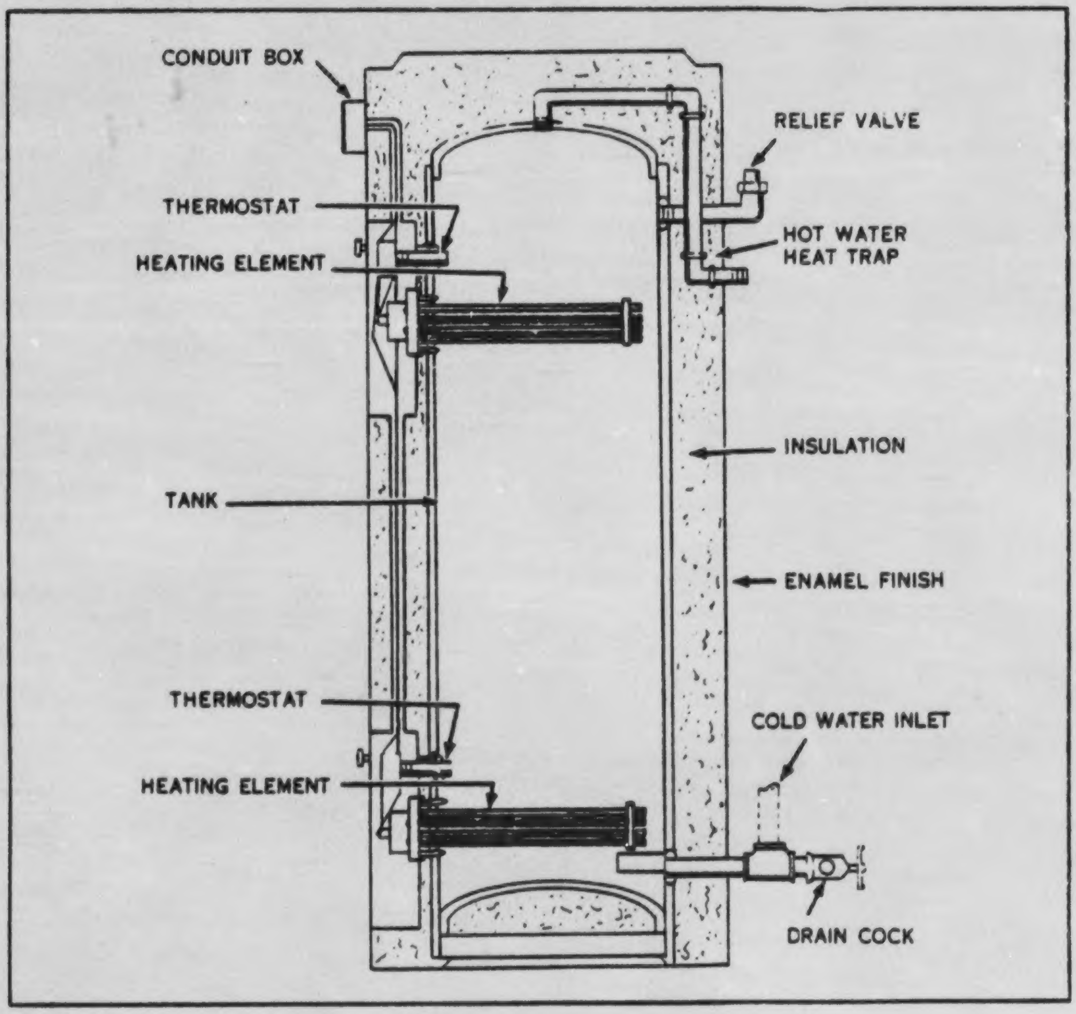

Figure 5-6. Typical construction of an electric water heater.

faucets. It has a fully automatic gas and water system. The instantaneous heater must be vented because of the exhaust gases that are injurious to human beings.

*Underwater line heaters.* Underwater line heaters are used in domestic water systems where hot water or steam is used for heating a residence. The body of the heater is constructed of cast iron with a built-in copper coil. The inlet and outlet openings of the coil are connected to the boiler heating plant below the waterline. The boiler water flows around the coils and heats the water. An underwater heater system is illustrated in figure 5-4.

*Solar heaters.* Solar heaters are coils mounted on the roofs of buildings so that the water flowing through the system can be heated by the sun. This type of system is used more extensively in oriental countries and has proved very efficient, especially in climates where the sun's rays are very hot. Often auxiliary heaters are installed in the system to heat the water during the winter months or during cloudy weather. When you install a solar heater, make sure that the sun coils face south and are set at the proper angle to get the maximum benefit from the sun. The top coil should be at least a foot below the bottom of the storage tank to insure that a sufficient amount of water remains in the coils.

*Automatic water heaters.* The most common residential heaters are water-heating units that are fully automatic. Whether the heaters are operated by natural or artificial gas, kerosene, or electricity, they are the most satisfactory heating systems on the market today.

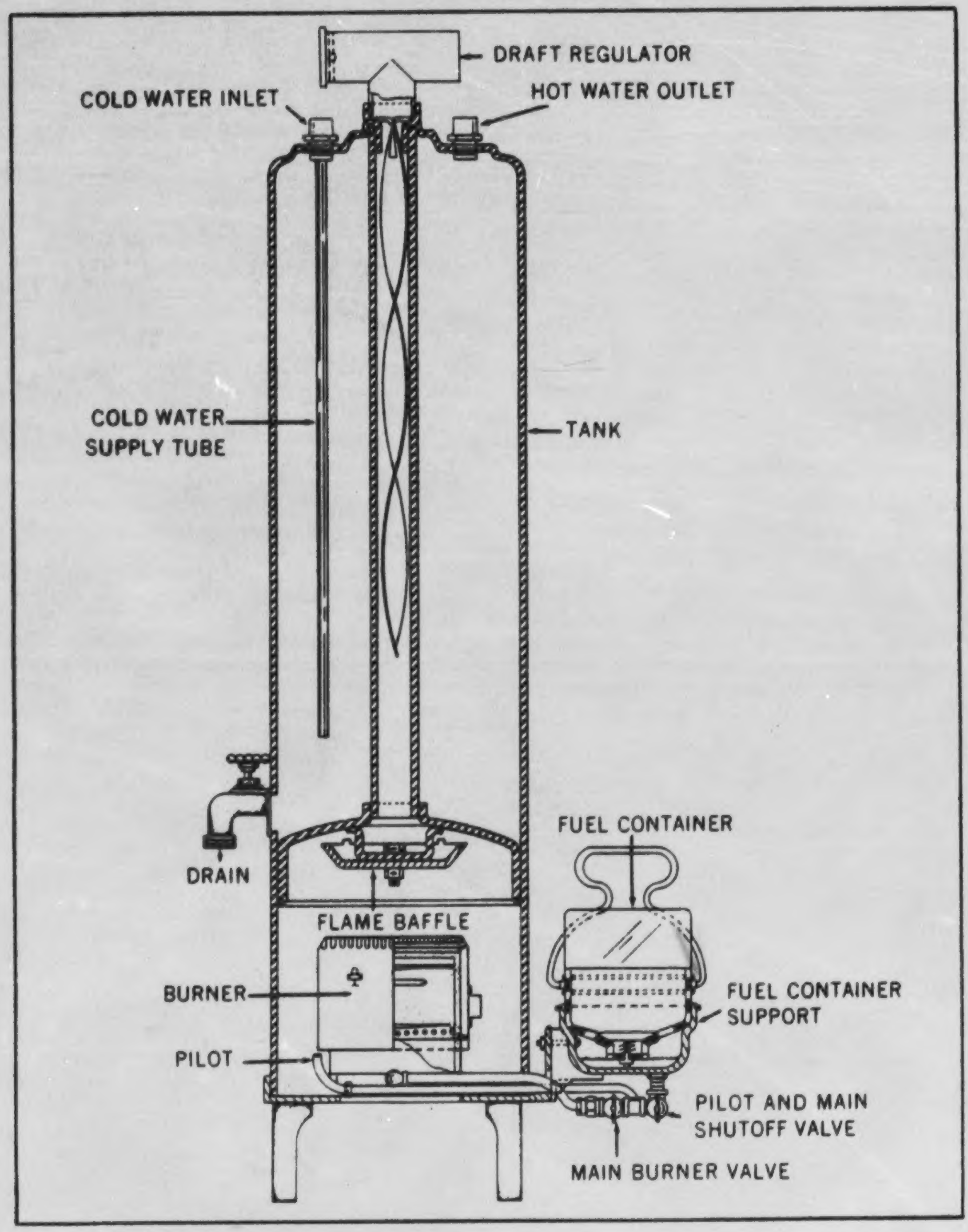
DRAFT REGULATOR
COLD WATER INLET
HOT WATER OUTLET
COLD WATER SUPPLY TUBE
TANK
FUEL CONTAINER
DRAIN
FLAME BAFFLE
BURNER
FUEL CONTAINER SUPPORT
PILOT
PILOT AND MAIN SHUTOFF VALVE
MAIN BURNER VALVE

Figure 5-7. Typical construction of a kerosene water heater.

They are compact units and are manufactured in different shapes and sizes with tank capacities of 10 to 82 gallons, and in exceptional cases, even larger. For example a small house trailer may have a 10-gallon water heater, whereas a 4-apartment complex may require a water heater of more than 100 gallons. These water heaters have many features that will keep them operating for a long period of time with a minimum amount of maintenance.

*a.* Gas water heater. The gas water heater, shown in figure 5-5, consists of a tank, burner, and flue. The tank is made of galvanized steel and is tested at 300 psi, with a working pressure of $127^{1}/_{2}$ psi. The tank is covered with an insulation which, in turn, is covered with a sheet of galvanized steel casing. The casing has a baked enamel finish. The flue in the tank has a deflector that baffles the burned gases to extract as much heat energy as possible. The draft hood is designed to prevent downdrafts and updrafts of the gas fumes during the operation of the heater. The temperature control is automatic and has only two positions of operation—the burner is full on or completely off, with only the tiny pilot light burning. The temperature control dial is designed with an arrow indicator, which can be set at any temperature from 80° F. to 180° F. The tank is equipped with a drain cock to which a garden hose may be connected for flushing and draining operations. The complete water heater has a safety gas control which shuts off the main burner gas supply if the pilot light is extinguished. The air control to the burner is the only adjustment of the burner flame.

*b.* Electric water heater. The electric water heater, shown in figure 5-6, is constructed in a manner similar to the gas water heater. It may be equipped with one or more heating elements. These elements may be located in or around the tank. The electric wiring is made with a special heat-resistant asbestos covering. The temperature of the water is controlled by a thermostat.

*c.* Kerosene water heater. The kerosene water heater, shown in figure 5-7, is also similar in design to the gas water heater. In general, it consists of a tank, flue, and burner. In addition, the heater is equipped with a glass fuel container which holds kerosene. This is inverted over a pressed steel support. Kerosene is supplied through two channels to the heating units. Two valves which are located immediately below the fuel container control the supply of fuel to these channels: one controls the supply to the pilot and the other controls the supply to the main burner only. Thus the burner may be turned completely off after use and the pilot may be left burning, which makes reignition possible by merely opening the main burner valve. The burner produces an intensely hot, blue flame, free from carbon and soot.

**Exercises (435):**

Mark the correct statements by placing an X in the spaces provided for those that are correct.

____ 1. Water heaters can be placed in three categories.
____ 2. The water-back water-heating system was probably the first method of heating water for domestic use.
____ 3. Most furnace coils are constructed of galvanized pipe.
____ 4. The instantaneous water heater needs no vent.
____ 5. The top coil of a solar system should be at least 1 foot below the bottom of the storage tank.
____ 6. The gas water heater is tested at 300 psi.
____ 7. All electric water heaters have only one heating element.

**436. Provided a list of responses and situations relating to the installation of water heaters, match the responses to the situation.**

**Installation of Water Heaters.** When you install a hot water heater, you are responsible for determining the location of the heater, unless it is specified in the

| Building | Gallons Per Person Per Hour |
|---|---|
| Residence | 8 to 10 |
| Factories | 4 to 6 |
| Schools | 2 to 4 |
| Apartments | 6 to 8 |
| Barracks | 8 to 10 |
| Offices | 4 to 6 |
| Dining Facilities | 7 to 10 |

Figure 5-8. Chart showing an estimate of hot water used per person.

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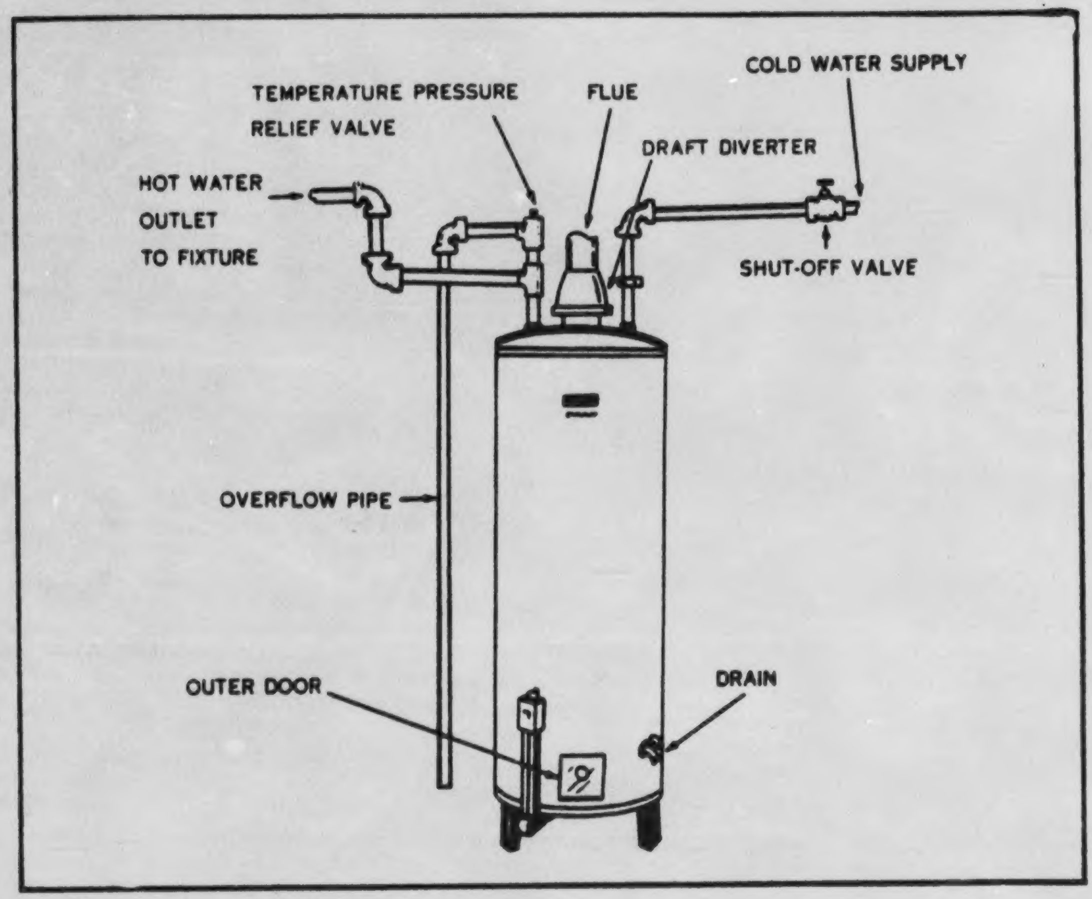


Figure 5-9. Pipe hookup to water heater.

blueprints. You are also responsible for determining the size of pipe to be used for the cold and hot water lines and for connecting the heater to a power supply. After it has been installed you must check its operation.

*Locating the heater.* If this is a new installation, check the blueprints or plans for the correct location of the water heater. You will find that it is a good practice to locate water heaters and tanks as close as possible to hot water risers to shorten the distance that the water must flow to reach the fixture. This procedure will reduce to a minimum the amount of cold water that must be drawn before hot water will reach the faucet. If you cannot place the water heater near the riser, the efficiency of the hot water system can be improved by covering long pipelines with some type of insulation.

*Sizing the heater.* To determine the correct size water heater or storage tank for a particular installation, you must consider three things: (1) the design of the building, (2) the number of occupants, and (3) the heating capacity of the unit.

*a.* Practical consumption. Practical tests have revealed that the amount of water used by an individual will range from 2 to 10 gallons per hour. Of course, this depends upon the type of building in which the system is installed and the purpose for which the water is used. A considered safe estimate of hot water required per person according to the type building is shown in the table in figure 5-8.

The values given in this table are based on water consumption for average uses. In a building such as a laundry, the size of the hot water system should be based on the water consumption of the individuals that work in the laundry building. The hot water consumption for swimming pool shower rooms is based on the number of individuals that the pool can accommodate.

*b.* Storage reservoir. If a storage tank is used, the size of the tank is determined by the size of the heating unit and the type of users. A large heating unit that

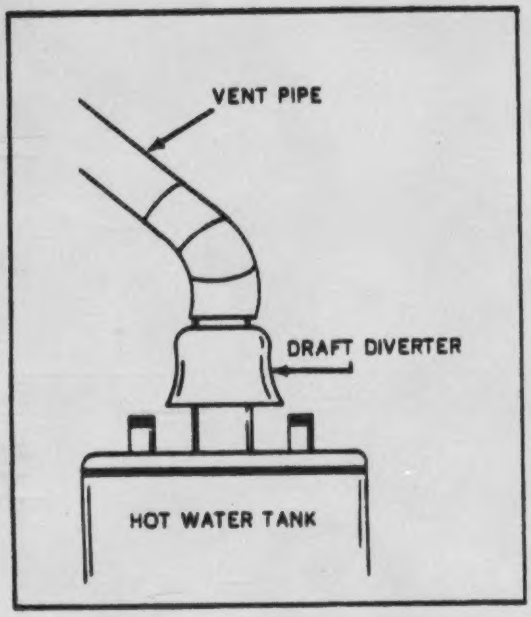


Figure 5-10. Water heater venting arrangement.

covers a large area may heat the water quickly and not require such a large storage tank.

*Setting up the heater.* Most manufacturers supply rough-in specifications for their water heaters so that the pipes can be alined accurately with the heater outlets. A flame type water heater should be located where an adequate amount of air is available for combustion. Local codes should be complied with before placing heaters and flues near combustible materials; other requirements should also be followed carefully. A typical installation of an automatic gas-fired water heater is illustrated in figure 5-9.

A water heater should be set as nearly level as possible. If the legs are not adjustable or if jacks are not provided to compensate for sloping floors, a concrete base should be built to take care of the slope.

*Venting the heaters.* Each flame type water heater should be equipped with a suitable draft diverter or vent hood, as shown in figure 5-10. This prevents a downdraft from affecting combustion or extinguishing the pilot light. It is a good practice to locate a flame type water heater where it can be vented through the roof or into a chimney. If the flue is connected to a chimney, the flue slope should not be less than 1/4 inch per foot. A 3- or 4-inch flue is large enough for the type of water heater used for domestic purposes. You should use a larger flue for water heaters used in commercial establishments. If a coal or oil burner heater is used, the flue should be 4 to 6 inches in diameter.

*Connecting the water pipes.* The heater outlets for connecting the hot and cold water pipes are marked on top of the heater near the opening. If the outlets are not marked, the hot water outlet is usually on your left as you face the front of the heater. The cold water supply pipe should be at least 3/4 inch (inside diameter) and should have a gate valve placed near the tank to cut off the water supply. The hot water line from the heater should be at least 1/2-inch galvanized pipe or 1/2-inch copper tubing. Unions are placed in the hot and cold water lines to disconnect the lines quickly when it is necessary to replace the heater. An overflow or drain drip pipe is usually connected to the temperature pressure-relief valve and extended down to within 6 inches of the floor.

The pipe for an electric heater is assembled in much the same way as that for a gas heater. It is a good practice to install the pipe first. Also, the electricians will usually install the outlets before the heater is installed. The electric heater is leveled the same way as a gas heater.

After the hot and cold water pipes have been properly installed, the system must be filled with water and checked for leaks. If a leak is detected you should repair the leaking joints.

*Connecting the gas supply.* Gas lines are installed within a building in the same manner as water lines; that is, the black iron pipe for the gas system is cut, reamed, and the joints are coated with joint compound the same as for galvanized water pipe.

Black iron pipe is largely used in gas distribution. If galvanized pipe is used, the gas will cause the galvanized coating to flake off and may stop the flow of gas through the fixture orifice.

*a.* Gas pressure for water heaters. The three types of working pressures used in gas systems are low, intermediate, and high. Normally, the Air Force uses intermediate pressure. Intermediate pressure is normally distributed at pressure up to 20 psi. Working gas pressure for hot water heaters is about 4 ounces; therefore, a service or pressure regulator is installed in the gas line to lower the pressure to 4 ounces.

*b.* Hookup for gas line. The minimum size black iron gas pipe that should be connected to a gas water heater is 1/2 inch. A union should be installed in the lines to permit easy disconnection when it becomes necessary to replace the heater. Some city codes may permit the plumber to install a short length of copper tubing to the heater to take the place of the union. A plug type valve (gas cock) should also be installed in the line so the gas can be cut off when it becomes necessary to remove or service the heater. When you install gas lines, be sure that they are supported with the proper hanger supports. Also keep in mind that you do not use any type of soldered joints. Only approved threaded pipe and fittings or flared tubing should be used.

*c.* Testing for gas leaks. After the gas line has been properly installed and before the system has been put

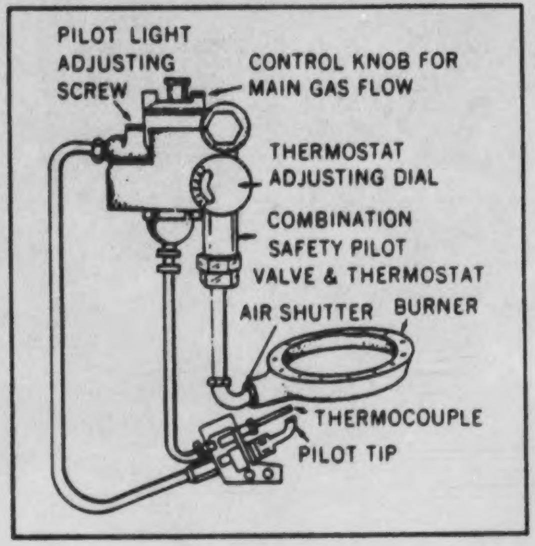

PILOT LIGHT ADJUSTING SCREW
CONTROL KNOB FOR MAIN GAS FLOW
THERMOSTAT ADJUSTING DIAL
COMBINATION SAFETY PILOT VALVE & THERMOSTAT
AIR SHUTTER
BURNER
THERMOCOUPLE
PILOT TIP

Figure 5-11. Automatic safety devices for a gas-fired water heater.

into service, it must be tested for leaks. Leakage of gas is wasteful and constitutes a serious hazard. Therefore, you should check a gas system even more closely than you would a water system. When testing a gas system, the plumber usually adds some element such as peppermint to the gas to give it an odor so that he can detect the leaks. Frequently, the gas leaks for long periods of time before it is detected when this type of test is used. The simplest test for leaks at joints or valves is the application of soap suds to the suspected area. Bubbles will appear on the pipe surface if there is a leak. If a leak is detected, it should be repaired immediately.

**Exercises (436):**

Match the responses in column B with the situations in column A.

*Column A*

____ 1. Location of a water heater in a new installation
____ 2. The flue for an oil burner water should be
____ 3. The flue for a domestic water should be
____ 4. The minimum size of water supply for a water heater
____ 5. The minimum size gas pipe for a water heater is
____ 6. The flue slope should not be less than

*Column B*

a. Three to four inches in diameter
b. One-half inch
c. As close as possible to the hot water risers
d. Four to six inches
e. One-fourth inch
f. Three-fourths inch

**437. Given some essential steps for starting a water heater, arrange them in the order that they should be performed, beginning with the first.**

**Starting the Hot Water Heater.** Before the gas cock is opened, make sure that the thermostat is opening and closing. This is determined by turning the adjusting dial back and forth on the low temperature end of the scale until a click is heard. The clicking sound indicates that the thermostat is operating properly. After this test, set the thermostat-adjusting dial to normal (140° F.) for ordinary use.

A gas-fired water heater should be equipped with some type of safety control, as shown in figure 5-11, to get the maximum protection from gas fumes. The automatic control shuts off the gas to the main burner when the pilot light goes out. As long as the thermocouple is heated by the pilot light, it will keep the main burner valve open; but when the pilot goes out, the thermocouple cools off, causing the gas valve to the main burner to close. The thermostat that extends into the hot water tank controls the gas to the main burner if the pilot light stays on. This thermostat is controlled by the temperature of the water inside the tank. After the pilot light burns for about 5 minutes, it should be adjusted to a soft blue flame about 1/2 inch high. This is accomplished by adjusting the pilot air shutter on some models and an adjusting screw on others. At the time you adjust the pilot light you should adjust the main burner so that it will have a soft blue flame. This is accomplished by regulating the air shutter.

Water heaters made by different companies have different types of heating units and automatic controls. You will be required to make certain adjustments on various types of water heaters. When you make the adjustments, follow the instructions given on the metal service plate mounted on each water heater, and

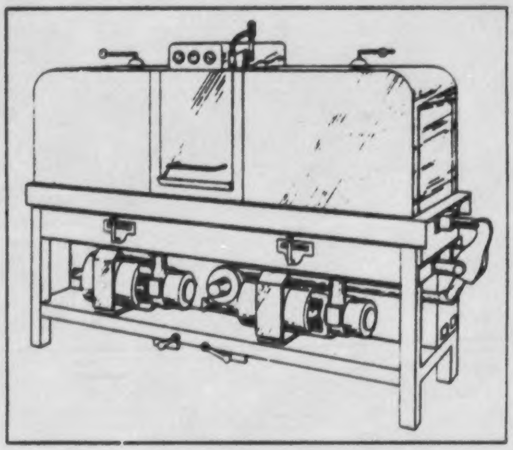
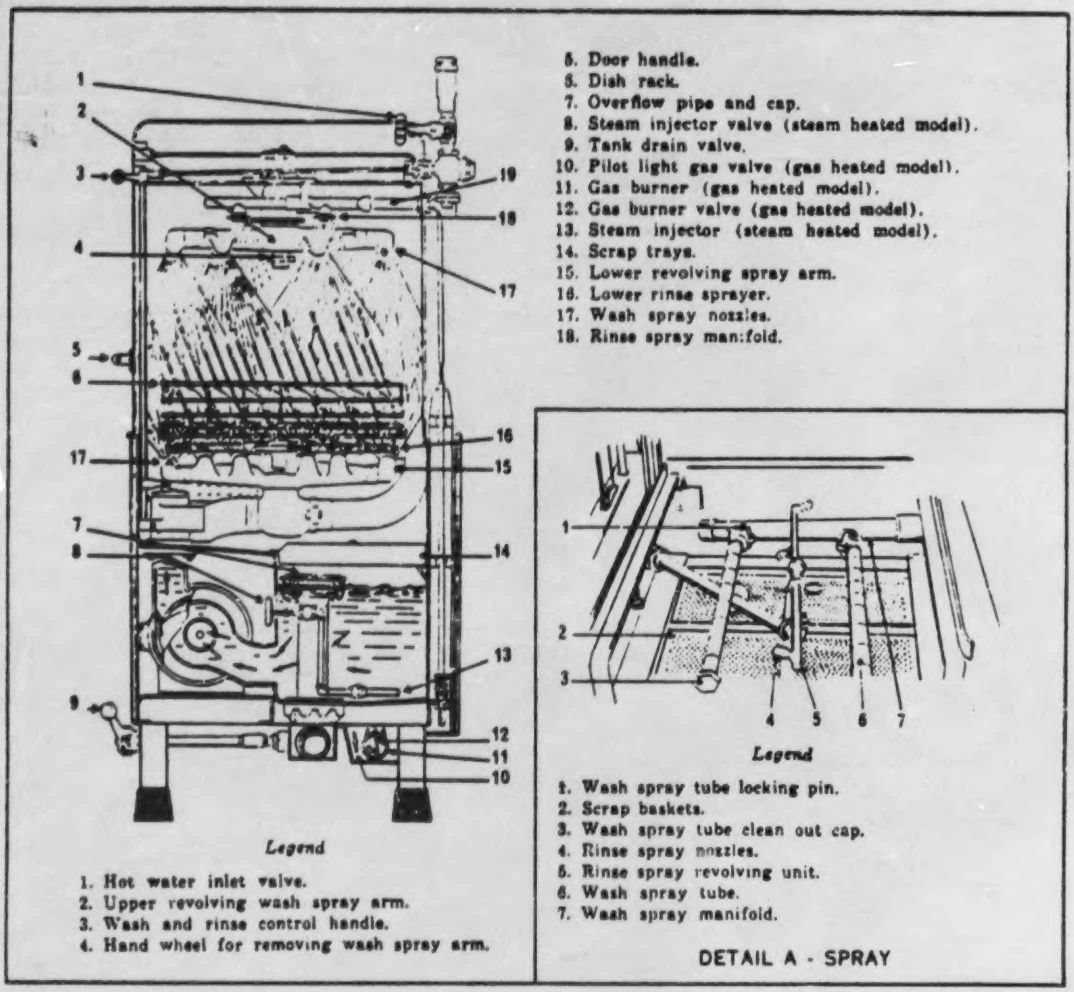


Figure 5-12. Overall view of a dishwashing machine.



*Legend*

1. Hot water inlet valve.
2. Upper revolving wash spray arm.
3. Wash and rinse control handle.
4. Hand wheel for removing wash spray arm.
5. Door handle.
6. Dish rack.
7. Overflow pipe and cap.
8. Steam injector valve (steam heated model).
9. Tank drain valve.
10. Pilot light gas valve (gas heated model).
11. Gas burner (gas heated model).
12. Gas burner valve (gas heated model).
13. Steam injector (steam heated model).
14. Scrap trays.
15. Lower revolving spray arm.
16. Lower rinse sprayer.
17. Wash spray nozzles.
18. Rinse spray manifold.

*Legend*

1. Wash spray tube locking pin.
2. Scrap baskets.
3. Wash spray tube clean out cap.
4. Rinse spray nozzles.
5. Rinse spray revolving unit.
6. Wash spray tube.
7. Wash spray manifold.

DETAIL A - SPRAY

Figure 5-13. Cross section of a dishwashing machine.

always keep in mind that to obtain the proper efficiency of any type of water heater, it must be properly installed and adjusted.

**Exercise (437):**

1. Arrange the following actions in the order that they should be performed.
   a. Set thermostat to 140° F.
   b. Adjust pilot light to soft blue flame about 1/2 inch high.
   c. Make sure thermostat is opening and closing.
   d. Adjust main burner to have a soft blue flame.
   e. Start pilot light.

**438. From a list of statements pertaining to maintenance of water heaters, select those that are correct.**

**Maintenance of Water Heaters.** There is very little maintenance required by water heaters. The storage tank on self-contained water heaters should be flushed every 6 months to remove scale, deposits, and corrosion that has accumulated inside the tank. The relief valve should be opened during inspection to insure proper operation, and the relief drain should be checked to insure that it is not plugged by debris or capped. The flue should be inspected to see that it is in proper position. The burners should be cleaned and adjusted when necessary. A properly adjusted burner will conserve costly fuel and will insure longer life for the heater. The magnesium anode should be inspected and replaced when necessary.

Electric water heaters should also be flushed and the anodes checked. The electrical wiring should be checked for worn insulation. Also the elements should be taken out and cleaned periodically. A small amount of preventive maintenance will insure a much longer life for any water heater.

**Exercises (438):**

Select the correct statements by placing an X in the appropriate spaces.

____ 1. Water heaters should be flushed every 6 months.

____ 2. Anodes in water heaters never need replacing.

____ 3. The relief valve on a water heater should be opened during inspections.

____ 4. The wiring on electric water heaters should be checked when performing maintenance inspections.

____ 5. Electrical heating elements should not be cleaned.

## 5-2. Dishwashers

Now that you know how to install, operate, and maintain water heaters, let's find out how the dishwashers that are used by the Air Force are installed, operated, and maintained.

Dishwashers are used to clean and sterilize soiled dishes and tableware. Spray type dishwashers used by the Air Force are available in double-tank automatic models and single-tank semiautomatic models. Before you install a dishwasher, you should understand some of its construction features. A dishwasher is constructed of metal and consists of wash and rinse tanks which are mounted on a supporting stand or frame. It is equipped with a motor-driven centrifugal water pump, piping, valves and controls, and a mechanical means of conveying racks of dishes through the machine.

### 439. Name the types of dishwashers used in AF messhalls and state the preferred final rinse temperature.

**Construction of a Dishwasher.** Dishwashing machines are used to wash and rinse kitchen utensils in a quick, sanitary, and efficient manner. They are manufactured in many different types, but the single- and double-tank types are the most commonly used in Air Force messhalls. An overall diagram of a dishwasher is shown in figure 5-12, and a detailed mechanism of a similar dishwashing machine is illustrated in figure 5-13. Usually the components of a dishwasher are the body, tanks, wash and rinse chambers, hot water booster, wash and rinse sprayer tubes, waterflow control handles, water mixing valve, doors, racks, conveyor, strainer trays, overflow pipes, drain control handles, pumps, control switch, and thermometer. The hot water booster is probably the most important component of the dishwasher. Its function is to furnish final rinse water at 180° F. to kill any bacteria that may be left after the washing process.

**Exercises (439):**

1. Name the two types of dishwashers that are used in Air Force mess halls.

2. What temperature should the final rinse be on a dishwasher?

### 440. Provided a list of situations associated with the installation of dishwashers, choose those that are correct.

**Installation of a Dishwasher.** The manufacturer's specifications should be followed as closely as possible when you install a dishwasher. In some cases, you may have to request additional instructions.

*Locating the machine.* Dishwashers should be located in a room or area specifically designated for dishwashing purposes. The area should be well ventilated, properly drained, and free from interference from other activities. The rough-in plumbing for new installations should be installed according to the measurements for supply openings recommended by the manufacturer. When you replace a dishwasher, you may have to alter the existing plumbing, unless the new machine is an exact replacement.

*Leveling procedure.* It is very important that dishwashers be installed perfectly level. Floors are not always level, especially when floor drains are installed. When the exact location of the machine is determined, it should be set on temporary blocks and leveled. After the machine is leveled on the blocks, the final and permanent leveling should be performed by adjusting the legs of the machine to the contour of the floor.

Some dishwashers have adjustments inside the wash and rinse chambers for leveling the sprayer tubes. The sprayer tubes should be leveled to insure efficient operation.

*Connecting the drain.* The next step in installing a dishwasher is to connect the machine drain to the sewer. Normally, a grease trap is not required if the dishes are prewashed by hand. If a grease trap is required, the dishwasher drain should have a straight run. You should use as few ells as possible when you make the connection. Two-inch pipe and fittings should be used for the drain.

*Connecting the water supply.* Most new dishwashers come from the manufacturer with the water supply inlets tagged for identification. Connect the hot water inlet to the hot water supply, and the cold water supply line to the cold water inlet on the machine. These connections are made with galvanized steel pipe, copper, or plastic.

Most dishwashing machines are equipped with booster heating units for raising the temperature of the rinse water. The heating units should be inspected and adjusted for proper performance. Most of the heating units are automatic in operation, and the temperature is controlled by a thermostat. Steam, gas, or electricity may be used as a source of heat.

When steam is used, the booster consists of a steam-heated copper coil and normally delivers 5 gallons of hot water per minute. The unit operates satisfactorily on a steam pressure of 35 psi. A gage is mounted in the steam line to register the steam pressure. When you install a dishwasher, inspect the steam coils to see that they are well mounted and in good condition. This type of booster requires only steam and water connections.

Gas burners are used as the source of heat on some boosters. When gas is used, check the components of the gas system and the piping and valves for leakage. The soap test may be used for these checks. Clean out the holes in the burner with a nonmetallic tool. Open the burner cock to the full open position and adjust the gas orifice and the air shutters until a soft blue-tinted flame is obtained. Adjust the flame to the desired height.

CAUTION: Before you light a gas-fired unit be sure the valves are closed and the unit has been aired out. Apply a lighted match to the pilot or burner immediately after you turn on the gas.

Electrical heating elements may be used in some boosters. When a dishwasher comes equipped with an electrically powered booster, the power requirement is usually the same as that for the electric motor in the machine. Examine the element and the insulation for defects or visual damage.

The building hot water supply may be inadequate for the proper operation of dishwashers in some installations. You have to install an auxiliary booster in the building hot water lines to increase the volume of hot water. These boosters are available in several sizes, and you should install one with a sufficient output capacity for the particular installation.

Dishwashers that have a steam-heated water booster must be connected to a steam supply. One-half-inch black iron pipe is used for this connection. A condensate return trap should be installed in the return line.

Domestic dishwashers are connected only to the hot water supply and drain. These dishwashers have a heating element built in for the final rinse. Dishwasher waste should discharge through an airgap to prevent waste from backing up and contaminating the dish compartment, as illustrated in figure 5-14.

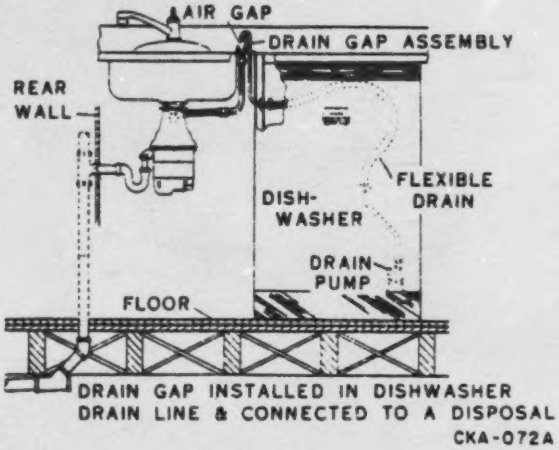


Figure 5-14. Domestic dishwasher installation.

*Operation of the dishwasher.* The dishwasher and lines and valves should be given a final visual inspection before the machine is operated. After the water reaches the operating temperature, the machine should be started. Check the operation of the conveyor and the sprayer assemblies. Trays of dishes should be run through the machine and the necessary adjustments should be made. Replace the inspection doors and make a final check to see that the machine is level.

NOTE: Complete operating instructions for the particular model and type of dishwashers installed in an area should be posted near the machines.

**Exercises (440):**

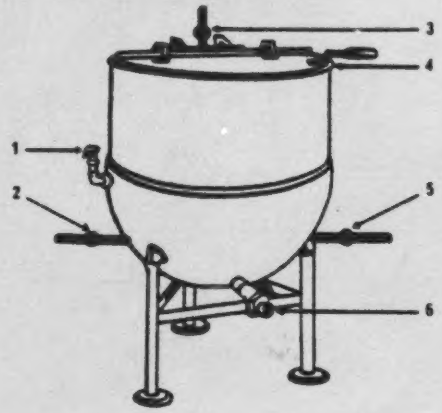
Choose the correct situation by placing a C in the appropriate spaces.

____ 1. Airman Jones installed a dishwasher in a messhall. He installed it in a well-ventilated area with a floor drain, and the area was free from interference from other activities. He used the manufacturer's specification as a guide.

____ 2. Mr. Wilson installed a dishwasher in the main messhall. He used 1 1/2-inch iron pipe with additional elbows to add to the flow of the drain.

____ 3. Sergeant Cummins installed a dishwasher that has a steam-heated water booster. He used 1/2-inch black iron piping to make the connection for the steam to the washer.

____ 4. Mr. Montz installed a domestic dishwasher without using an airgap in the drain.



1. Safety valve and trapped air release.
2. Steam outlet valve.
3. Water inlet valve.
4. Lid.
5. Steam inlet valve.
6. Draw-off faucet.

Figure 5-15. Conventional steam-heated kettle.

**441. Provide brief answers to pertinent questions on maintenance of dishwashers.**

**Maintenance of a Dishwasher.** The dishwasher requires a considerable amount of maintenance. This maintenance may include repairing water leaks, cleaning spray nozzles, adjusting gas burners, oiling motors, cleaning screens, adjusting conveyors, repairing valves, etc. You should procure and follow the manufacturer's instructions when you perform maintenance on a dishwasher.

The screens and drain pipes of the dishwasher become plugged with broken glass and food particles. The operator of the dishwasher has the responsibility for keeping the screen clean and free of debris. The plumber will maintain the water and waste piping to and from the dishwasher.

**Exercises (441):**

1. What source of information should be consulted when performing maintenance on dishwashers?

2. Who has the responsibility for keeping the screens cleaned in a dishwasher?

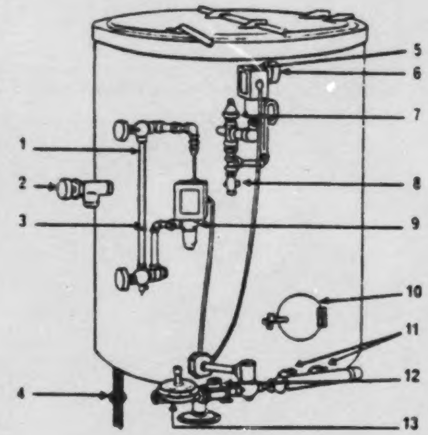
3. Who has the responsibility for maintaining the water and drain pipes to dishwashers?

### 5-3. Steam Kettles

Steam-jacketed kettles are important units that are used by cooks in preparing food. They are ideal for cooking large quantities of food quickly. You are responsible for locating and installing the kettle so that it will serve the personnel who are using it in the most efficient manner.

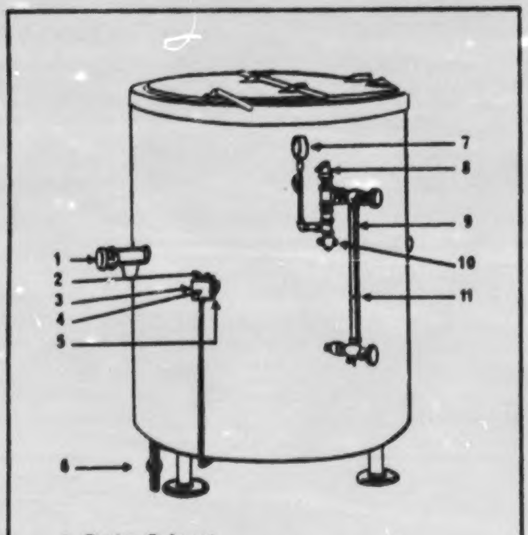
**442. Choose the true statements related to the construction of steam kettles.**

**Construction of Steam Kettles.** Generally speaking, there are three types of steam-jacketed kettles: steam-heated, gas-heated, and electrically heated kettles. These kettles are illustrated in figures 5-15, 5-16, and 5-17. Steam kettles are manufactured in 20-, 40-, 60-, and 80-gallon capacities, and operate on a steam pressure of 30 to 40 pounds per square inch (psi). The components of the steam-jacketed kettle are the inner and outer shell, cover, safety valve, drain-off faucet, steam supply valve, strainer, low-water cutoff, pressure control, glass gage, air vent, and pressure gage.



1. Water jacket gauge glass.
2. Draw-off valve.
3. Water jacket water level mark.
4. Water inlet valve.
5. Electrical control switch.
6. Steam pressure gauge.
7. Safety valve.
8. Trapped air release pet-cock.
9. Low water cut-off valve.
10. Inspection door.
11. Gas burner valves.
12. Pilot valve push button.
13. Gas pressure regulator.

Figure 5-16. Gas-heated steam kettle.



1. Drain-off faucet.
2. Electrical switch button.
3. Signal light.
4. Electrical control box.
5. Thermostat.
6. Water inlet valve.
7. Steam pressure gauge.
8. Safety valve.
9. Water jacket gauge glass.
10. Trapped air release pet-cock.
11. Water jacket, water level mark.

Figure 5-17. Electrically heated steam kettle.

**Exercises (442):**

Choose the true statements by placing a T in the appropriate space(s).

____ 1. The three types of jacketed kettles are the steam heated, gas heated, and fuel heated.

____ 2. Steam kettles are manufactured in capacities ranging from 20 to 80 gallons.

____ 3. Steam kettles operate on 5 to 10 pounds of pressure.

____ 4. The safety valve, drain-off faucet, and pressure gage are components of steam kettles.

### 443. Select the correct statements concerning the installation of conventional steam kettles.

**Installation of a Conventional Steam Kettle.** The conventional steam kettle, shown in figure 5-15, is operated by steam from a steam boiler. Follow the manufacturer's installation instructions when you install this type of steam kettle.

*Location of the kettle.* The kettle should be bolted on a sloping floor near a floor drain so that the water used to wash the kettle may drain away.

*Steam supply.* To control the incoming steam when repair work is being performed, a steam control valve may be installed in the steam inlet line near the kettle. Most manufacturers recommend that a pressure-reducing valve be installed in the steam supply line near the kettle to reduce the pressure if the steam supply pressure is greater than the working pressure stamped on the kettle.

*Steam condensate.* The steam condensate return line should be connected to the steam outlet on the kettle. It is advisable to install a suitable steam trap in the condensate return line near the kettle.

NOTE: Do not install a vapor vent pipe on the kettle.

*Water supply.* The water supply pipe should be installed near the kettle. If the kettle is tapped for a water connection, install a globe valve in the cold water supply line near the kettle and provide an airgap in the line where it runs downward into the kettle. If the kettle is not tapped for a water connection, terminate a cold water line at an unobstructed swing spout faucet so that the water can flow into the kettle when required. Where there are many kettles installed in one area, install swing spout faucets between the kettles so that each faucet may serve two kettles.

After the kettle has been installed, it should be checked for proper operation. See that the steam is not leaking anywhere and that the thermostats are set properly and operating.

**Exercises (443):**

Select the correct statements by placing a C in the spaces provided.

____ 1. The steam kettle should not be bolted on a sloping floor.

____ 2. You should follow the manufacturer's instructions when installing a conventional steam kettle.

____ 3. It is not advisable to install a steam trap in the condensate return line near the steam kettle.

____ 4. Where there are several steam kettles installed in a row, you should install a swing spout faucet between the kettles so that each faucet will serve two kettles.

### 444. Answer pertinent questions relating to maintenance of conventional steam kettles.

**Maintenance of a Conventional Steam Kettle.** The maintenance of a conventional steam kettle is mostly done by dining hall attendants. It includes the cleaning of the interior surfaces and the strainer with soap and water each time it is used. The users should also clean the drain-off pipe and the drain-off valve each day. If the kettle is not used for a few days, it should be checked for steam valve leakage.

When there is an indication of valve leakage, remove the faulty valve and inspect the seat and disc. Clean the valve seat and disc, and check to see if the leaking condition has been stopped. If the valve continues to leak, reface the disc or replace the unit. When you reinstall valves after repair, place a few drops of light oil on the valve packing and the valve stem. If the drain valve is damaged beyond repair, it should be replaced with another valve similar in design. Do not replace a drain valve with a common gate valve. Once a year, or more often if necessary, the safety valve must be checked under operating conditions. If the valve does not operate properly after it has been cleaned and reseated, it must be replaced with a new safety valve. Steam trap repairs are usually made to remedy failures caused by leaking discharge valves or punctured floats or buckets. Other causes are improperly operating parts. Causes of failure are generally corrected by cleaning and refacing the seat of the discharge valve. Some steam traps have a small vent in the bottom of the bucket. Do not seal this vent, because it is required for proper operation of the trap.

**Exercises (444):**

1. How often should the drain-off pipe and drain-off valve be cleaned when in use?

2. If a steam kettle has not been used for a few days, what should be checked?

3. How often should the safety valve on a steam kettle be checked?

**445. Given statements concerning the installation of a gas-heated steam kettle, mark the true statements.**

**Installation of a Gas-Heated Steam Kettle.** The gas-heated steam kettle, shown in figure 5-16, operates on steam just like the conventional steam kettle but makes its own steam from the heat produced by the gas which it uses. In this way it is a self-contained unit. The gas-heated steam kettle is more dangerous to operate than the conventional steam kettle because it burns gas. Gas may explode or cause suffocation.

*Location of the gas-heated steam kettle.* The gas-heated steam kettle should be installed in a depressed floor area near a drain in a manner similar to that of the conventional steam kettle.

*Gas supply.* The gas-heated steam kettle should be connected to the gas main with a line large enough to supply the maximum amount of gas that the burner requires. Tables showing the pipe sizes required to serve gas-heated units with either natural or manufactured gas are provided by the manufacturer. A gas shutoff valve should be installed near the kettle. It should be equipped with a safety guard so that the gas cannot be turned on accidentally. An adjustable, spring-loaded gas pressure regulator must be installed in the gas line as near the kettle as possible. After the regulator has been installed, it must be adjusted to the correct pressure.

*Venting a gas-heated steam kettle.* The venting of the kettle is important and is accomplished by installing the kettle under a ventilating hood. You should extend the vent pipe full size from the vent connection of the gas burner to the underside of the hood. If there is no ventilating hood, install a full-size vent pipe from the vent connection of the gas burner through the roof. Install a draft diverter in the vent pipe, and make sure that the vent pipe is unobstructed. Be sure that the fumes and gases cannot be blown back into the building by downdraft.

*Water supply.* If the kettle is designed with a water supply tap, install an airgap in the vertical supply line near the kettle and a globe valve above the airgap. Connect this assembly to the kettle. If the kettle does not have a tap, terminate a water line at an accessible height above the kettle and install an unobstructed faucet at this point to permit water to flow into the kettle when desired.

**Exercises (445):**

Mark the true statements by placing a T in the appropriate space(s).

____ 1. The gas-heated steam kettle is the least dangerous of all steam kettles to operate.

____ 2. A gas shutoff valve should be installed near the kettle.

____ 3. Gas-heated steam kettles need no vent pipe.

____ 4. Steam kettles designed with a water supply tap should have an airgap installed in the vertical supply line near the kettle.

**446. Provide brief answers to questions pertaining to the operation and maintenance of gas-heated steam kettles.**

**Operation and Maintenance of a Gas-Heated Steam Kettle.** When the kettle is installed, you should check it for operation. The gas and the primary air supplied to the burners should be properly proportioned for efficient operation. Open the burner cock to the full open position and adjust the gas speed orifice and the mixer shutters until a soft blue-tinted flame is obtained. Turn the flame to a position where it just touches the kettle. If the flame is too high, it will produce a fine soot which is apt to deposit on and damage the kitchen equipment and utensils.

The maintenance performed on a gas-heated steam kettle is similar to the maintenance performed on the conventional steam kettle. However, in addition, the gas burner and the pilot light should be cleaned every week. Disassemble the burner assembly and clean the holes through which the gas passes with a nonmetallic tool. This type of tool is used to keep from enlarging the holes.

**Exercises (446):**

1. What color should the flame be when the gas burner is properly adjusted on a gas-fired steam kettle?

2. How high should the flame be adjusted on the gas-heated steam kettle?

3. How often should the pilot light be cleaned on a gas-heated steam kettle?

**447. Identify the true statements pertaining to the installation of an electrically heated steam kettle.**

**Installation of an Electrically Heated Steam Kettle.** The electrically heated steam kettle, shown in figure 5-17, operates on steam just as the conventional steam kettle, but the energy used to convert the water to steam is produced by an electrical current. This kettle is a self-contained unit just like the gas-heated kettle. Since it is operated by electricity, care should be taken to avoid shocks from the current.

*Location of the electrically heated steam kettle.* The electrically heated steam kettle should be located in a convenient place in the kitchen near a drain and where a supply of water and a source of electrical power are readily available.

*Electrical supply.* The electrical connection to the kettle must be made by a qualified electrician. He should install the necessary wiring, switches, and circuit breakers according to the codes that are being followed for the particular area.

**Exercises (447):**

Identify the true statements by placing a T in the appropriate spaces.

____ 1. The electrically-heated steam kettle operates on steam just as the conventional steam kettle.

____ 2. The electrical steam kettle is not self-contained

____ 3. The electrical steam kettle should not be located near a drain.

____ 4. The electrical connections to the electrical steam kettle should be made by a qualified electrician.

**448. Given a list of statements pertaining to the operation and maintenance of electrically heated steam kettles, distinguish between those that are correct and those that are incorrect.**

**Operation and Maintenance of an Electrically Heated Steam Kettle.** The electrically heated steam kettle is operated by an electrical current and controlled by a thermostat. Set the thermostat to the desired degree of heat. Do not set the thermostat beyond 285° F., because the safety valve is set at 40 pounds of pressure, which is equivalent to 287° F. Close the petcock under the safety valve when the steam begins to escape through it. When the heat in the kettle reaches the desired degree which is set by the thermostat, the red signal light will go off. This shows that the unit is at its proper temperature.

The electrically heated steam kettle is cleaned in the same manner as are the conventional and gas-heated steam kettles. Be sure to turn off the electrical power to the kettle before you clean it. Failure of the electrical element is a job for the electrician. If it cannot be repaired, it should be replaced with a new element or a new kettle. The electrical kettle is not used as much as the other types; therefore, most of your installation and maintenance will be on the steam- or gas-heated steam kettles.

**Exercises (448):**

Distinguish between the correct and incorrect statements by placing a C in the spaces provided for those that are correct and an I in the appropriate spaces for those that are incorrect.

____ 1. The electrically heated steam kettle is controlled by a thermostat.

____ 2. The thermostat on the electric steam kettle should not be set beyond 285° F.

____ 3. Failure of the electrical element is a job for the plumber.

____ 4. The electrical kettle is used more often than other types of kettles.

## 5-4. Sinks, Laundry Tubs, and Laundry Equipment

Now that you know how to install and maintain steam kettles, let's consider some other units that are used in the kitchen, in connection with the kitchen units, and in the laundry. These units are sinks, laundry tubs, and laundry equipment.

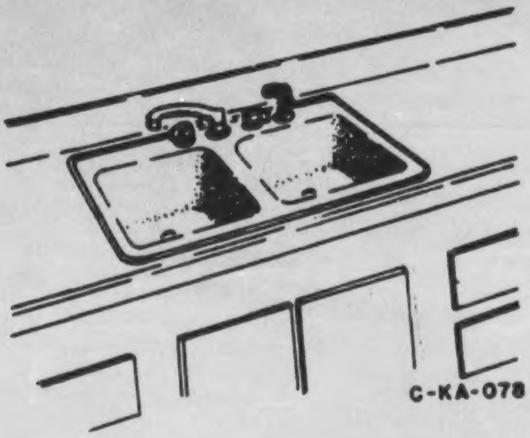


Figure 5-18. Counter-mounted sink.

**449. State required information pertaining to the installation and maintenance of kitchen sinks.**

**Kitchen Sinks.** Kitchen sinks are manufactured in a number of different patterns to be used for specific purposes. The type most frequently encountered is the sink shown in figure 5-18. It is made of either enameled steel, enameled cast iron, or stainless steel and is available in a number of different patterns and sizes. It may have either a single or a double bowl.

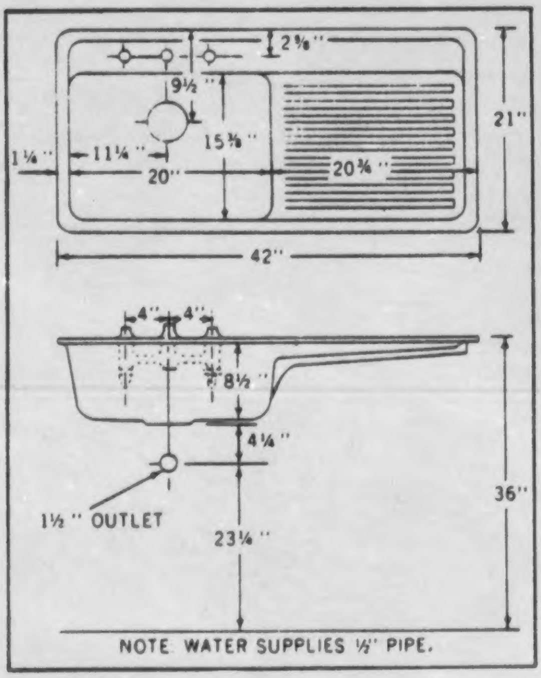


Figure 5-19. Rough-in specifications for a kitchen sink.

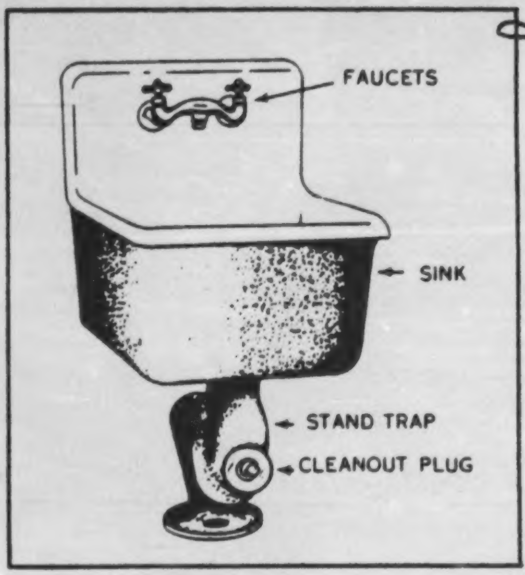


Figure 5-20. Utility sink.

depending upon its size. Many flat-rimmed sinks are mounted by clamps and have a plastic counter top. This makes a colorful installation, but it is not as durable nor as easy to keep clean as the skirted enameled sink.

*Installation of kitchen sinks.* The rough-in specifications for a kitchen sink are shown in figure 5-19. Always study the specifications before you install any type of kitchen sink. Even though you have installed other types of sinks, you must follow the specifications as listed by the manufacturer for the particular sink that you are installing.

The kitchen sink is hung from a bracket which is screwed to a mounting board in a position so that the sink, when mounted, will be at a convenient height for use. The distance between the floor and the top of the drainboard should be 36 inches. After the bracket has been screwed into place, the sink is lowered into position on the bracket so that the lugs cast on the back of the sink fit down into the corresponding notches in the bracket. The strainer and tail piece are screwed into the sink bowl, and the trap is connected to the rough-in waste. The last step in the installation of the kitchen sink is to select a suitable faucet, install it on the sink, and connect the water supply to it.

*Maintenance of kitchen sinks.* The maintenance of kitchen sinks is usually confined to the removal of stoppages and the repair of water supply faucets. Minor stoppages in the trap may be removed with a force cut. If this procedure is not effective, remove the stoppage through the trap cleanout. If the stoppage is beyond the trap, you may have to remove the trap and run a sink snake down the waste pipe to dislodge the stoppage.

**Exercises (449):**

1. What type of materials are kitchen sinks made of ?

2. The drainboard on a kitchen sink should be what distance from the floor?

3. What is the last step in the installation of a kitchen sink?

4. What tool should be used to remove minor stoppages from kitchen sink traps?

**450. From a given list of statements concerning the installation and maintenance of utility sinks, choose the correct statements.**

**Utility Sinks.** The utility sink, shown in figure 5-20 (sometimes called slop or service sink), is used especially for dumping mop buckets and washing mops. It has a deep bowl and is generally constructed of cast iron and finished in enamel.

*Installation of utility sinks.* The utility sink installation is similar to the kitchen sink installation. The utility sink is also mounted on a bracket and mounting board. In addition to the hanger, the utility sink also has a built-in adjustable stand trap which bolts to the floor and provides a pedestal support. The stand trap should be adjusted to take most of the weight off the hanger and prevent the unit from sagging. After the fixture has been set in place, the waste line is connected to the water supply. Then, the unit is ready for use. Typical rough-in specifications that will aid the plumber when installing a utility sink are shown in figure 5-21.

*Maintenance of utility sinks.* The maintenence of utility sinks is the same as for kitchen sinks. You will probably be called to clear clogged drains or fix leaky faucets.

**Exercises (450):**

Choose the correct statements by placing a C in the appropriate spaces for those that are correct.

____ 1. Utility sinks are used especially for dumping mop buckets and washing mops.

____ 2. Utility sinks are designed with shallow bowls.

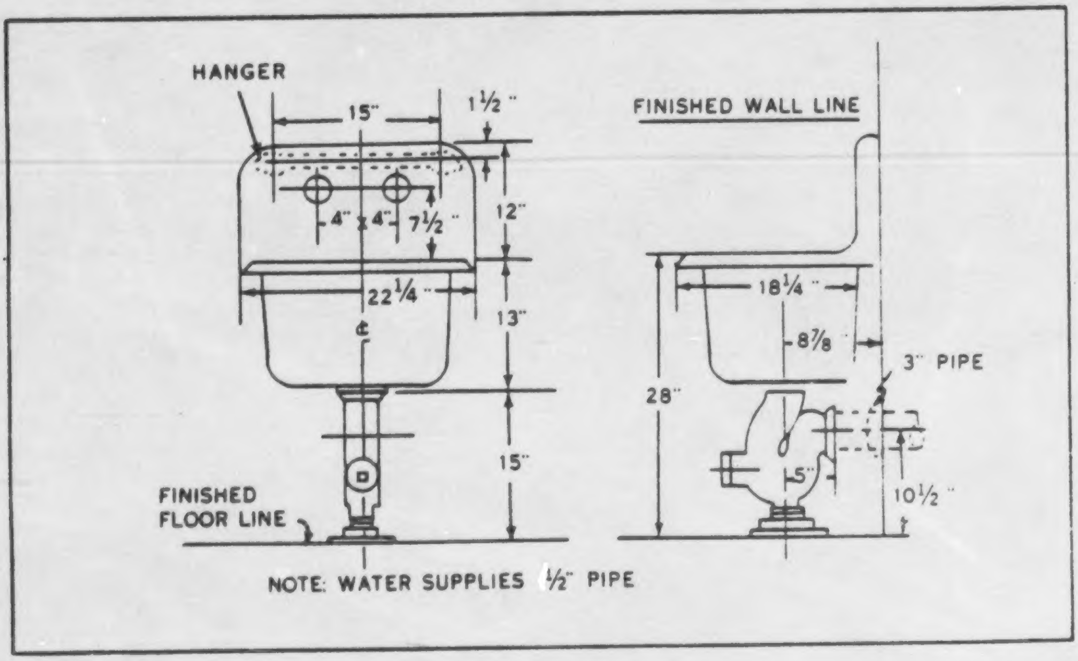


Figure 5-21. Rough-in specifications for a utility sink.

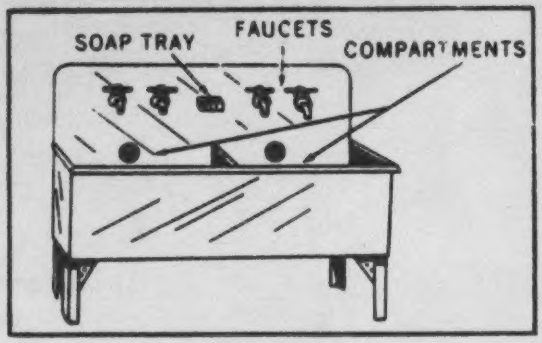


Figure 5-22. Scullery sink.

____ 3. The stand trap on a utility sink should be adjusted to take most of the weight off of the hanger.

____ 4. The maintenance of utility sinks is the same as for a kitchen sink.

____ 5. Utility sinks are generally constructed of plastic.

### 451. Identify the true statements related to the installation and maintenance of scullery sinks.

**Scullery Sinks.** Scullery sinks (see fig. 5-22) are large deep vessels that are used to wash vegetables and pots and pans. They are usually constructed of galvanized sheet iron or stainless steel. These sinks are manufactured in one, two, and three compartment types. Since these sinks are used to wash greasy pots and pans, the waste must drain through a grease trap (see fig. 5-23). A scullery sink does not need a fixture trap, the grease interceptor acts as a trap for the fixture.

*Installation.* Scullery sinks are not commonly found in residences. They are installed in large kitchens such as clubs, cafeterias, and military messhalls. Consult the rough-in specifications for the scullery sink you are installing before you connect the water and drain lines. If a food grinder is installed on a scullery sink, it must discharge directly into the building drain through a P-trap. Food grinders should not discharge into a grease interceptor.

*Maintenance.* Maintenance on a scullery sink consists mainly of cleaning the grease trap, repairing the food grinder, unclogging the drain, and repairing the faucets.

**Exercises (451):**

Identify the true statements by placing a T in the appropriate spaces.

____ 1. Scullery sinks are constructed of galvanized sheet iron and stainless steel.

____ 2. Scullery sinks are only manufactured in one- and two-compartment sizes.

____ 3. The manufacturer's rough-in specifications should be consulted before the water supply is connected to the scullery sink.

____ 4. Food grinders should not be discharged into a grease trap.

____ 5. Scullery sinks are used to wash vegetables, pots, and pans.

### 452. Choose the correct statements associated with the installation and maintenance of laundry tubs.

**Laundry Tubs.** Laundry tubs are usually installed in basements or in utility rooms and are used for soaking, washing, and rinsing clothes.

*Construction of laundry tubs.* Laundry tubs are made in single- and double-compartment styles. They are usually constructed of concrete, like the one shown in figure 5-24, but a unit made of enameled iron is sometimes used. Laundry tubs are usually supported by metal stands.

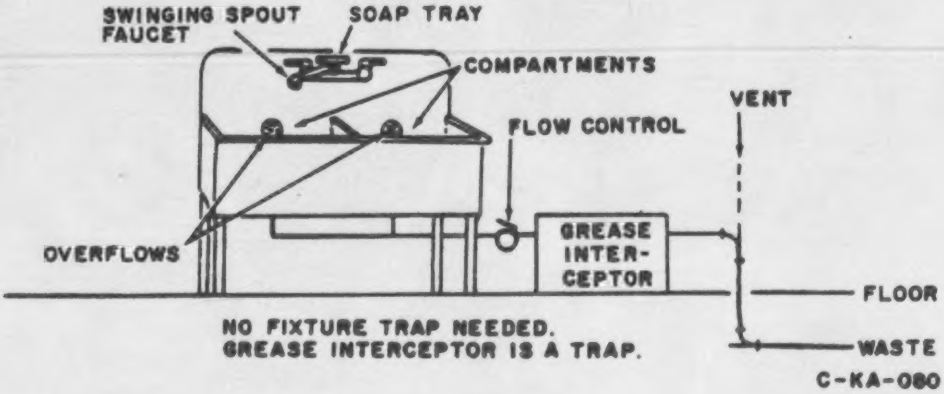


Figure 5-23. Scullery sink installation.

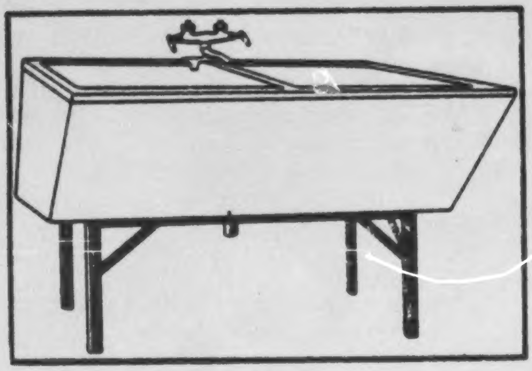


Figure 5-24. Double-compartment laundry tub.

*Installation of laundry tubs.* Before you begin to install a laundry tub assembly, be sure to refer to the manufacturer's installation specifications. The installation specifications for a typical set of laundry tubs are illustrated in figure 5-25.

When you install a laundry tub, first assemble the metal stand by bolting the components together. Place the stand in a convenient location in front of the rough-in piping. Place the laundry tub on the stand. Be sure you have plenty of help for this operation. When the tub is set on the stand, shift it so that the P-trap can be connected to the tailpiece of the tub. Be sure the laundry tub is set evenly on the stand and that the legs are properly shimmed. Some laundry tubs are equipped with special bolts located at the bottom of the legs which are used to level the tubs. Laundry tubs come with cast-in waste connections with nickel-plated brass strainers, rubber stoppers, and a 1½-inch tailpiece. The P-trap for laundry tubs should be of heavy brass construction with a cleanout. It should be assembled in a manner similar to that for a lavatory trap. The installation of the tub is completed by connecting a swing type combination faucet to the hot and cold water supply lines to provide water for the fixture. Usually the faucet is provided with a hose bib which permits the attachment of hoses.

*Maintenance of laundry tubs.* The maintenance performed on laundry tubs is the same as that for sinks.

**Exercises (452):**

Choose the correct statements by placing a C in the appropriate spaces.

____ 1. Laundry tubs are manufactured in three and four compartments.

____ 2. The first thing to do when installing a laundry tub is to assemble the stand.

____ 3. Laundry tubs come with cast-in waste connections.

____ 4. The P-trap for laundry tubs should be of heavy brass.

____ 5. All laundry tubs are equipped with adjustable legs.

**453. Given statements pertaining to installation and maintenance of laundry equipment, mark the correct statements.**

**Laundry Equipment.** The major items of laundry equipment used at Air Force bases include washers, extractors, tumblers, presses, ironers, and starch cookers. Most of these units are automatic but must be attended by operators. Usually theses machines operate on electricity or gas, but steam and hot water may also be required.

Laundry washers are used for washing fabrics, such as clothes, curtains, bed linen, etc., by mechanical operation. A laundry washer consists of a motor-driven, perforated cylinder which revolves inside the shell. The perforated cylinder washes the fabrics by tumbling them. The filling and draining of the wash water is automatic. Laundry washers are of different sizes, depending upon their requirements.

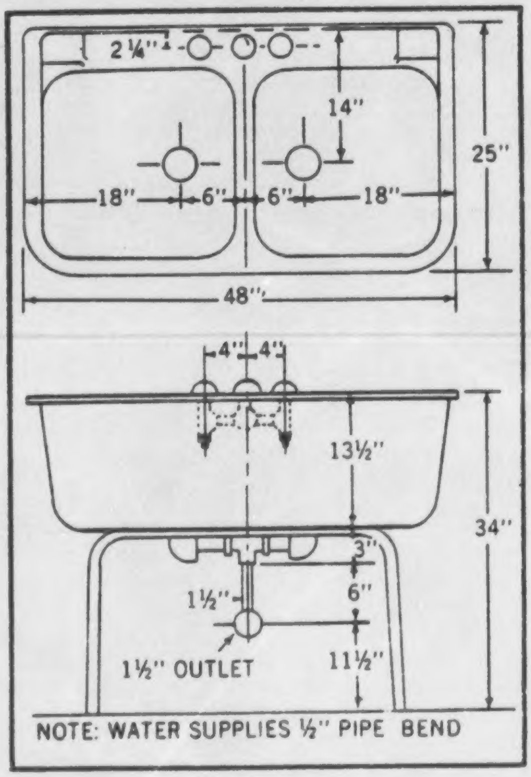


Figure 5-25. Laundry tub rough-in measurements.

*Installation.* When you install a laundry washer, refer to the manufacturer's installation procedures. If they are not available, install the machine in this manner. Position the washer before it is uncrated. Set the washer near a drain, level it, and bolt it to the floor. Connect the cold and hot water supply lines, drain, and motor leads. Check the rotation of the cylinder and lubricate the parts. Operate the machine and make the necessary adjustments.

Extractors are machines which remove most of the water from fabrics by centrifugal force. An extractor consists of a motor-driven, perforated, galvanized-steel basket, open at the top, which rotates within a metal shell. The size of an extractor is determined by the inside diameter of the basket measured in inches. When you install an extractor, refer to the manufacturer's installation instructions. If they are not available, follow the installation instructions for a laundry washer, since these directions are applicable.

Laundry presses and ironers are used to finish (iron) certain types of fabrics. There are a number of different kinds of presses and ironers; however, they all operate on the same principle. Most presses and ironers are constructed of a steel frame, which supports the steam chambers, table, and operating mechanism. The steam chambers are in the head and back of each unit, and are designed for a steam working pressure of approximately 100 psi.

When you install a steam press or ironer, refer to the manufacturer's installation instructions. If they are not available, follow the installation procedures applicable to laundry washers.

Starch cookers cook starch for use in the laundry. The cooker consists of an inner and outer shell of corrosion-resistant metal separated by insulation. A brass draw-off cock is provided in the side at the bottom of the shell to remove prepared starch. A starch cooker of this type may be designed in a variety of sizes, depending upon the requirements of the installation. When you install a starch cooker, refer to the manufacturer's installation instructions. However, if these instructions are not available, install the cooker in a manner similar to that for a laundry washer. In addition, install a steam supply and condensate line.

*Maintenance.* Maintenance of laundry equipment will consist of repairing valves, tightening anchor bolts, unclogging drains, replacing worn parts, and the replacing equipment.

**Exercises (453):**

Mark the correct statements by placing an X in the spaces provided.

____ 1. Washers should be positioned before they are uncrated.
____ 2. Washers need no leveling when installed; they are self-leveling.
____ 3. Extractors remove water from clothes by centrifugal force.
____ 4. Laundry presses operate on 50 psi.
____ 5. Starch cookers are equipped with a brass draw-off cock.

## 5-5. Auxiliary Plumbing Equipment

As a plumber, you will be responsible for installing and maintaining auxiliary plumbing equipment. This equipment includes pumps, pneumatic lines, pneumatic sewage ejectors, and water meters. You will also be anchoring these units to floors, walls, and different structural members of the building.

### 454. From a given list of statements concerning water pumps, select those that are correct.

**Pumps.** For the purpose of our discussion, pumps are divided into three groups: the well, circulating, and sump pumps. Most of these pumps are similar in design.

*Water well pumps.* Water well pumps are usually vertical, centrifugal, or turbine pumps driven by electric motors. The motors may be mounted above or below the water level. When the pump motor is mounted above the water level, it is called a submerged pump. Pumps with the motor mounted below the water level are submersible pumps. Submerged pumps are usually used for shallow well pump operation, whereas submersible pumps are used for deep well operation because of their adaptability to different depths.

The submerged pumps are of the centrifugal, vertical type. Their motors are generally mounted near the well head and are coupled to the pumps by a shaft. The length of the shaft depends on the depth of the well. Since long pump shafts vibrate, it is better to use the submersible type of pump for deep wells.

The submersible, centrifugal pump, shown in figure 5-26, is of the multistage, vertical design. Each stage consists of a bowl and impeller. The pump impeller, impeller shaft, and bowl assembly are made of stainless steel to prevent corrosion. The pump shaft is connected directly to the motor by a splined coupling. The motor is located below the pump and takes the thrust of the pump on a thrust bearing. The motor is designed specifically for submerged operation. Operation of the motor out of water is apt to cause it to burn out. Submersible pump motors are usually three-phase, 60-cycle, and operate on either 220 or 440 volts. Some small pump motors use 110 volts. These motors are liquid filled and prelubricated at the factory and require no servicing before operation. Water well pumps must always be installed according to the manufacturer's specifications.

*Circulating pumps.* Circulating pumps are used to pump water for different purposes. These pumps are of the centrifugal type with a single stage and have a horizontally split case, as shown in figure 5-27. The

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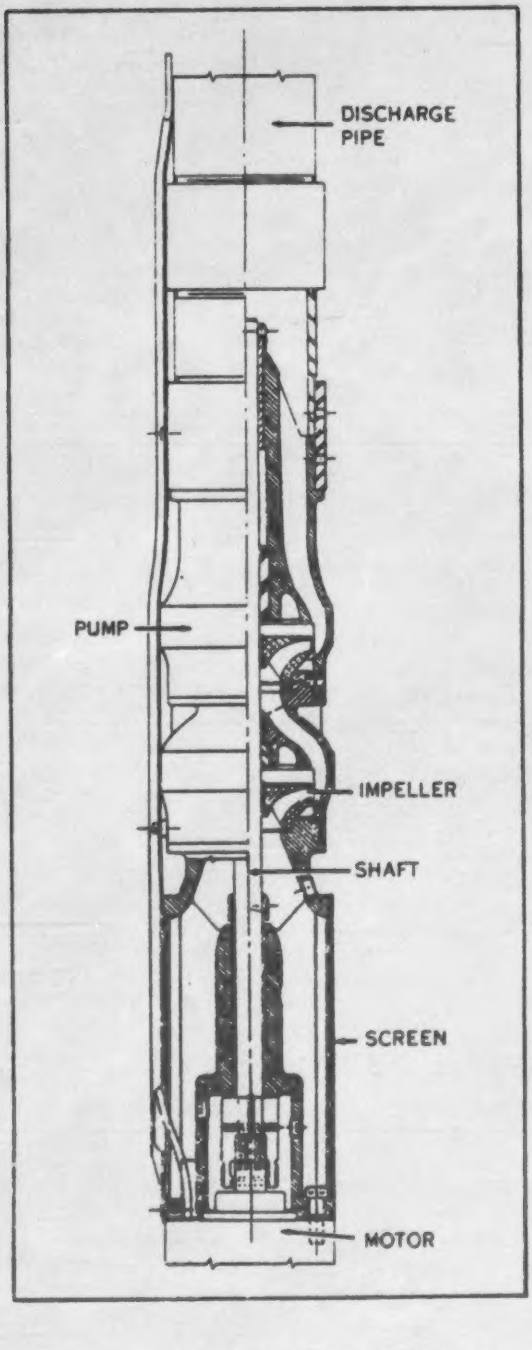

Figure 5-26. Centrifugal, submersible well pump.

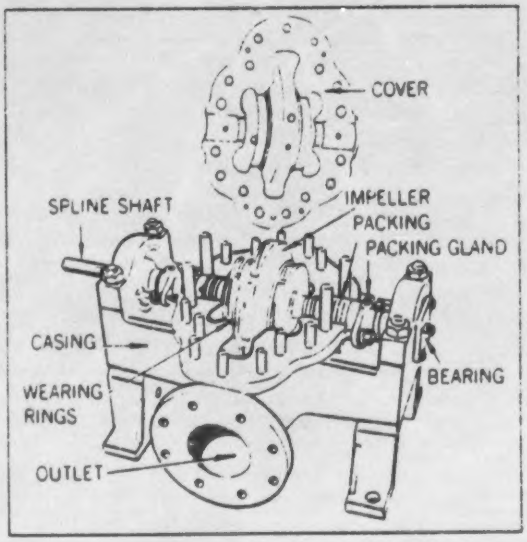

Figure 5-27. Circulating pump.

pump impeller is of the double suction type (inlet on each face of impeller), made of bronze, and is mounted on a shaft which extends the width of the pump. The impeller is set in the casing with very little clearance. Wearing rings are provided in the casing and impeller to maintain the proper running clearance and to minimize wear between the moving and stationary parts of the pump. Pump packing and stuffing boxes are located on each end of the impeller shaft where it extends through the pump casing. One end of the shaft terminates in a bearing. The other end of the shaft passes through a bearing and is splined for attachment of the flexible coupling that connects the pump to the motor. Circulating pumps must also be installed according to manufacturer's specifications.

*Sump pumps.* The sump pumps that you will be required to service are, like the well pumps, the submerged and the submersible.

The submerged, centrifugal sump pump is of the vertical type, similar to a well water pump, with the motor mounted above the liquid level. A centrifugal, submerged sump pump is shown in figure 5-28. Most of these pumps are operated by a float-controlled switch that, in turn, operates the pump motor.

The other type of sump pump is the submersible type, shown in figure 5-29. The motor in this pump is hermetically sealed so that it can operate in a liquid such as water. The pump is similar to the deep well pump, with the motor positioned below the pump in the water in the sump. These sump pumps are usually made of stainless steel to prevent corrosion. Sump pumps are used to remove wastes.

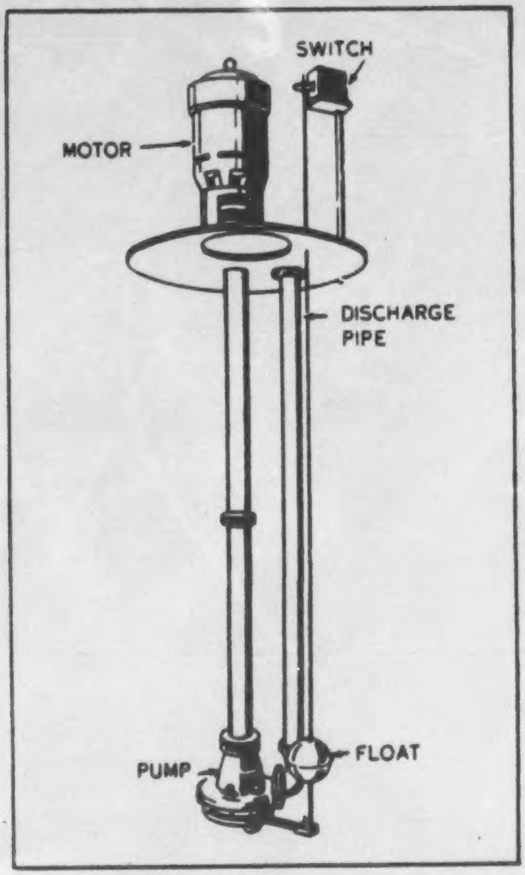

Figure 5-28. Centrifugal, submerged sump pump.

*Maintenance of pumps.* Water pumps should be maintained in accordance with the manufacturer's instructions. When pump capacity slacks off noticeably, the pump should be carefully checked. If the impeller and seal parts are worn beyond the limits recommended by the manufacturer, the parts should be replaced. The reconditioning of a pump should take place when it is on standby. If this procedure is not practical, the pump should be removed and replaced with a spare. Minor maintenance, such as tightening the packing nuts, may be done when the pump is in service and running. The packing may be replaced when the pump is not operating.

**Exercises (454):**

Select the correct statements by placing a C in the appropriate spaces.

____ 1. Pumps with the motor mounted below the water level are submersible pumps.

____ 2. The length of a pump shaft depends upon the horsepower of the motor.

____ 3. Manufacturer's specifications should always be followed when installing pumps.

____ 4. The pump impeller for a circulating pump is of the single-suction type.

____ 5. Most sump pumps are operated by a float-controlled switch.

____ 6. Reconditioning of pumps should take place when they are on standby.

### 455. Given pertinent questions relating to watermeters, provide brief answers.

**Watermeters.** Watermeters are devices that measure and record the amount of water that flows through a pipe. They are used to record the amount of water that is used by a consumer. The construction of a watermeter is shown in figure 5-30.

In buildings with basements, watermeters are usually installed just inside the basement wall. A stop-and-waste cock is provided to shut off the water in a building when the water supply system needs to be

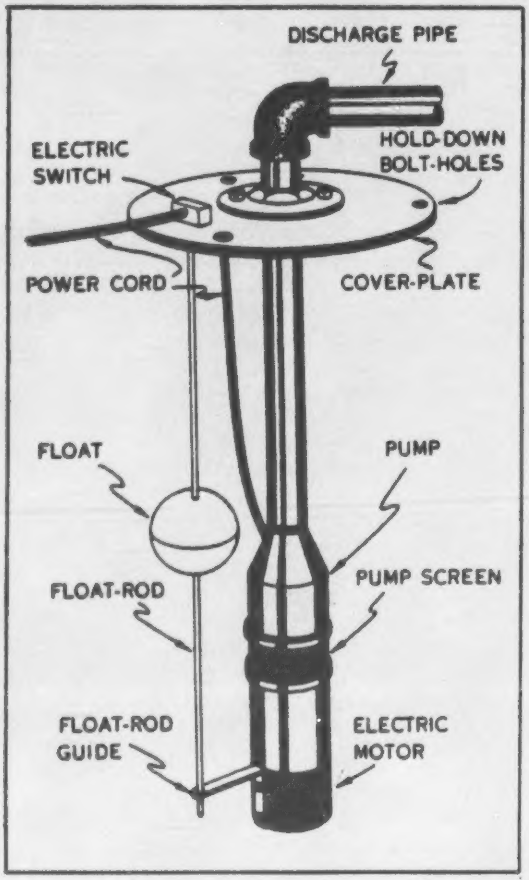

Figure 5-29. Centrifugal submersible sump pump.

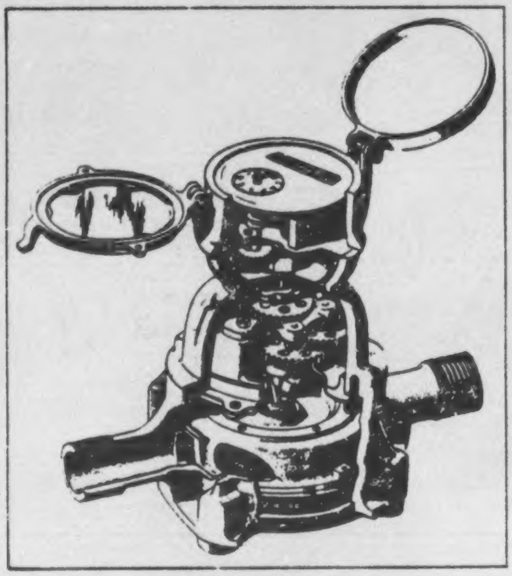

Figure 5-30. Cross section of a water meter.

drained. In buildings without basements, watermeters are installed in buried meter boxes which are placed somewhere between the curb and the building. These meters are installed below the frostline to keep them from freezing. The meter box is made of cast iron and is equipped with a lid that is self-locking. The box is buried over the meter with the door flush with the surface of the ground. A watermeter is installed in the water line between two sections of pipe. The fittings on the pipe ends are screwed, as appropriate, to the inlet and outlet connections on the meter. Be sure that you place the meter in the line so that the arrow on the case points in the direction of waterflow.

To read a meter that is installed in the ground, the meter box lid must be unlocked with a special key. The amount used is indicated on the dial.

Watermeters require very little maintenance. They usually work satisfactorily for years unless they are damaged by freezing or a hard blow. When a watermeter fails to operate, it is usually removed and replaced with a new or reconditioned unit.

**Exercises (455):**

1. What is the purpose of watermeters?

2. Where are watermeters installed when the building has a basement?

3. Of what types of materials are meter boxes made?

4. What should be done when a watermeter fails to operate properly?

**456. Provided a list of statements pertaining to pneumatic sewage ejectors, choose the true statements.**

**Pneumatic Sewage Ejectors.** Pneumatic sewage ejectors are vessels that collect waste below ground level and force it to a place of disposal above ground level. They operate on air pressure. The amount of waste they are capable of transferring is determined by the size of the unit. A diagram of a pneumatic sewage ejector is shown in figure 5-31. The pneumatic sewage ejector is installed in the line between two sections of pipe by connecting the pipe fittings to the appropriate inlet and outlet connections on the sewage ejector.

The pneumatic sewage ejector consists of a main body or pot, inlet and outlet openings, an air pressure connection, electrodes, and an inspection opening. The pot is constructed of welded carbon steel in the form of a cylinder with a dished top and bottom. The inside of the pot is free from burrs or rough edges which might obstruct the free passage of solids and rubbish usually found in sewage. The inlet and outlet openings are usually flanged to facilitate the attachment of valves. A check valve is installed next to the sewage ejector pot, and a gate valve is installed next to the check valve. The gate valve stops the flow of sewage through the pneumatic sewage ejector pot and

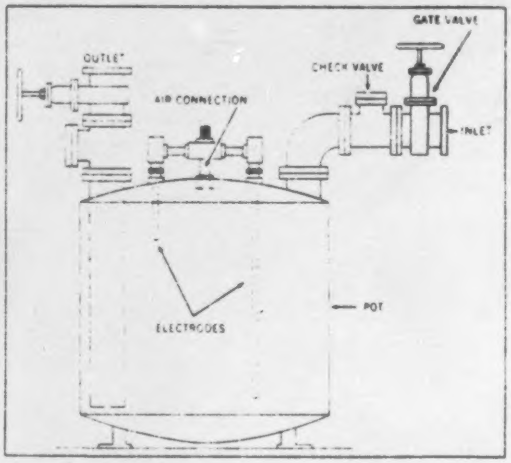

Figure 5-31. Pneumatic sewage ejector.

check valves during maintenance and repair. The air connection on the top of the sewage ejector is used to admit compressed air into the pot to force sewage out.

The sewage ejector is controlled by a solenoid valve which opens and closes automatically on a signal from electrodes inside the pot. There are two of these electrodes, one short and one long. The sewage ejector does not operate continuously, but rather in cycles. As the sewage enters the sewage ejector, nothing happens until the sewage reaches the upper (or short) electrode. When this occurs, the solenoid valve is energized, and compressed air is delivered to the sewage ejector to empty the pot. When the sewage level drops below the end of the long electrode, the solenoid valve opens to shut off the air and release the air pressure from the pot to the atmosphere. This operation completes an ejection cycle of the sewage ejector.

Sewage ejectors must be inspected and maintained if they are to operate properly. One of these inspections is to determine how long it takes to empty the pot. This is done by pressurizing the pot. The discharge time should be within the limits of the normal operating time of the sewage ejector. If it takes longer than normal, it is an indication of an inoperative valve or an obstruction in the line. Air leaks in the line reduce the action of the pot. The check valves should be checked periodically. They are held open sometimes by foreign matter which allows the waste to flow back to the inlet line. Clean check valves that are leaking; replace valves if cleaning is not effective. The electrodes should be removed periodically and cleaned of the grease and foreign matter which usually accumulate on them. The inside of the pot should be cleaned when necessary.

**Exercises (456):**

Choose the true statements by placing a T in the appropriate spaces.

____ 1. Pneumatic sewage ejectors are vessels that collect waste below ground level and force it to a place of disposal.

____ 2. Pneumatic sewage ejectors operate on water pressure.

____ 3. The inlets and outlets on pneumatic ejectors are usually flanged.

____ 4. There are two electrodes inside the pot of the pneumatic sewage ejector.

____ 5. The check valves on the outlet side of the pneumatic sewage ejector never need inspecting.

**457. Given a list of statements concerning pneumatic and vacuum lines, choose the correct statements.**

**Pneumatic and Vacuum Lines.** Compressed air and vacuum are required to operate various types of instruments, devices, and equipment at most large installations and especially at missile sites. In some cases, air pressure is used to operate pneumatic valves, transmitters, and various types of controllers. It is also used to pressurize domestic water systems and sewage ejectors. Aerators depend on compressed air for their operation, and demineralizers depend on it for regeneration. To keep these units operating efficiently, you will be required to install and maintain pneumatic and vacuum lines that serve these units.

Pneumatic controls or instruments, to operate efficiently, must be connected to a regulated air supply. The air must be clean and dry and have the proper pressure. The installation must be planned to prevent water, oil, or dirt from entering the system and contaminating the units.

Compressed air systems usually operate on pressures up to 100 psi. This pressure may or may not be reduced before it is used by the various instruments and devices. Copper tubing and copper or steel pipe may be used to fabricate air lines. Steel pipe and its threaded fittings are usually galvanized as a protection against internal corrosion, which is often bad because of moisture in the air. Flared type connections should be used when you use copper tubing.

The tubing, pipes, and fittings must be clean inside and free from burrs. Thread compound should be applied to the male threads. The supply header should be pitched from 1/8 to 1/4 inch to the foot toward a drain to help remove entrained oil and moisture. Low sections of the pipe system should be equipped with water traps or drain valves to collect the condensed moisture.

Gate valves are generally used in headers and principal branches, and globe valves are installed at hose connections and other outlets. A large receiver tank is provided sometimes at a reciprocating compressor outlet to reduce the air pulsations created by the compressor and to serve as a separator to collect moisture.

Pneumatic lines are installed in the system by connecting them to the inlet and outlet openings of units in the system. These lines must be supported to reduce vibration, which may cause the pipes to crack and break. The lines may be anchored to the building structure with clamps, braces, and brackets.

Pneumatic pipes and supports should be inspected periodically and the necessary maintenance performed. This maintenance may include the replacement of pipes, fittings, and gaskets. When you are maintaining copper tubing, the work may consist of soldering the fittings and tubing. Silver soldering may be necessary, depending upon the specifications for the type of fittings and lines. It will be your responsibility to repair leaks that occur in tubing by the insertion of flared type connections. You will also be required to replace defective sections of screwed galvanized-iron pipe. After you repair a penumatic line, apply pressure and test it with a soap solution to determine if it is still leaking.

**Exercises (457):**

Choose the correct statements by placing a C in the spaces provided for those that are correct.

____ 1. Pneumatic controls and instruments must be connected to a regulated air supply to operate efficiently.

____ 2. Compressed air systems usually operate on pressures up to 50 psi.

____ 3. Copper tubing, copper pipe, and steel pipe may be used to fabricate air lines.

____ 4. Soldered joints should be used to make connections on copper tubing.

____ 5. Gate valves are generally used on headers and principal branches.

____ 6. Supply headers should be pitched 1/8 to 1/4 inch toward a drain.

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# Preventive Maintenance and Corrosion Control

ONE OF THE MOST important jobs you will perform as an Air Force plumber is preventive maintenance for the various plumbing installations on the base. You make periodic inspections to determine the need for repairs or the replacement of damaged pipes and fittings. You perform minor repairs to prevent major damages from developing. Therefore, it is of great importance that you understand what preventive maintenance is and how it applies to Air Force plumbing systems.

The following paragraph is quoted from former President Herbert Hoover:

> It is only through the elimination of waste and the increase in our national efficiency that we can hope to lower the cost of living on the one hand and raise our standard of living on the other. The elimination of waste is a total asset. It has no liabilities.

Along that same line, Master Plumber Stormy Weathers said, "Corrosion will do more damage in 6 months to Air Force plumbing and equipment than an enemy agent can do in a lifetime. To a plumbing specialist, corrosion is our number one enemy." The mission of the Air Force will be jeopardized if some vital system is rendered unserviceable by corrosion. So, you see, you will play an important role in meeting the mission of the Air Force by controlling corrosion in plumbing systems on your base.

This chapter covers procedures for inspecting plumbing installation, pipes out of alinement, types of pipe damage, temporary pipe repairs, and permanent pipe repairs. It also covers uniform corrosion, localized corrosion, and compositional corrosion. It tells how corrosion affects metals that are under stress; discusses corrosion caused by nonelectrolytes and electrolytes, materials least likely to be affected by scale and corrosion, coatings and wrappings for corrosion protection, galvanic cathode protection, and field test equipment for cathodic protection; and explains maintenance of anode systems and impressed current systems.

## 6-1. Preventive Maintenance

The preventive maintenance program is conducted throughout the Air Force and at every Air Force base. Each base has a maintenance section that is responsible for preventive maintenance. This section includes such trades as plumbing, sheet metal, heating, electrical work, carpentry, and painting. Preventive maintenance keeps buildings in repair and equipment in usable condition, and prevents breakdowns which would slow operations or stop them completely.

**458. From a given list of statements associated with inspection of plumbing systems, choose those that are correct.**

**Inspection Procedures.** When inspecting any plumbing installation, you should conduct a visual inspection first, noting all repairs required. The minor repairs should be made immediately, and the major repairs or replacements should be scheduled and completed as soon as possible. During inspection, special attention should be given to corrosion, rust, splitting or cracking of pipes or fittings because of freezing, excessive strain, etc. Such damage should be corrected.

When the visible and exposed piping have been inspected, then the pipes in unlighted places must be checked. This means that a light must be used to complete the inspection. Do not use an open flame unless you are sure that there is no danger of explosion or fire. An electric safety light, such as an electric drop cord, is much safer. It is usually harder to find leaks located in dark areas, and especially in cases where the leak is extremely slow (such as a drop every 10 to 20 minutes) or the water pressure is too low to cause a steady drop. One method of locating these leaks is by placing a piece of white paper under the suspected leak. If there is a leak, the paper will be stained after the water dries.

Quite often a pipe will leak on one floor level and water will seep to the level below. This situation calls for other methods of detection, such as placing your ear against the pipe and tracing the sound to the leak. The volume of the sound will increase as you near the damage. The sound may also be increased by using a strip of wood as a resonator. Place one end of the wood against your ear and the other against the pipe and trace the sound to the leak in the same manner as by the ear method. In large buildings it is sometimes difficult to find leaks. In such cases, you will have to resort to other methods to detect and magnify the sound developed by the water passing through the holes or cracks in the pipe.

*Pipes out of alinement.* When a plumbing system is installed in a building, the pipes are placed in a horizontal or vertical position, or at some other desired angle. It is also intended that they will remain in that position permanently unless for some reason they must be changed. If a building sags, leans, shifts, or settles unevenly, it is likely that the pipe will be forced out of its proper alinement. When this happens, an excessive strain is placed upon the pipe that may eventually damage it. Since the strength of pipe is reduced considerably where it is threaded, cracks and breaks usually occur in this area. Pipes that are not properly blocked, braced, or supported with hangers will vibrate, and the vibration may cause cracks or breaks at the joints. Therefore, keeping installed pipes in proper alinement and well supported is very important in preventing costly repairs.

*Types of pipe damage.* Pipes can be damaged in many different ways, but we will cover only the damage to pipes that the plumber can prevent when installing a plumbing system. Often a plumber is careless in doing his work, and failures occur quickly after the installation is completed. When installing a section of pipe, the plumber sometimes finds it to be somewhat short. He then decides to back off one or more of the fittings to make the proper connection. Once pipe and fittings are turned up tight, only slight unscrewing will loosen the joint enough to cause a leak. Pipe dope is not used to seal leaking joints; they must be tightened properly. Sometimes damage is the result of turning or tightening fittings too tight, thereby stretching the fitting to the extent that it cannot be used again to make a sealed joint. Overtightening fittings will also cause them to crack. Damage commonly found in the threaded area of pipe consists of crossed, torn, flattened, mashed, stripped, or chipped threads. This is usually caused by dull die cutters or insufficient lubricant while the threads are being cut. Fittings with stripped threads are a result of excessive tightening or cross-threading.

*Temporary pipe repairs.* Leaks in a pipe system require either temporary or permanent repairs. Small or slow-flowing leaks may be stopped by temporary repairs. These repairs are intended to be relied on for only a short length of time, possibly for a day or even a shorter period. Major repairs must be regarded as permanent repairs; and when they are made, the system should be as good as it was when it was originally installed. The new replacement can be expected to give satisfactory service for the life of the material used in the repair. However, since the rest of the pipe system is old, more leaks are apt to occur any time. For this reason, it is desirable to replace any pipe which seems to be weak because of the action of corrosion. Before you make any kind of repairs on plumbing systems, be sure to shut off the water and relieve the pressure from the system.

*a.* Plastic tubing. Another way to make a temporary repair in a pipe is to replace the damaged section with plastic tubing. Cut the pipe on either side of the leak with a hacksaw or a regular pipe cutter, if working space permits. Now, remove the damaged pipe section and replace it with a length of rubber hose or flexible plastic tubing by slipping the ends over the pipe and securing them with hose clamps, as shown in figure 6-1. The inside diameter of the hose or tubing must be equal to the outside diameter of the pipe. One-inch automobile hose fits 3/4-inch pipe, and 3/4-inch garden hose fits 1/2-inch pipe.

*b.* Caulking with lead. Cracks and small holes in a pipe or fittings may be repaired by filling them with lead. Successful caulking is more difficult than using iron cement.

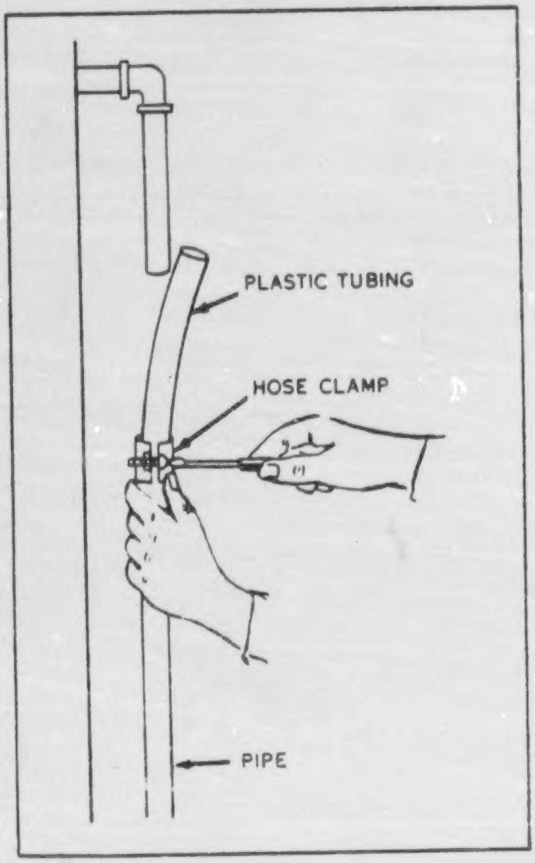

Figure 6-1. Repairing a hole in a pipe with plastic tubing.

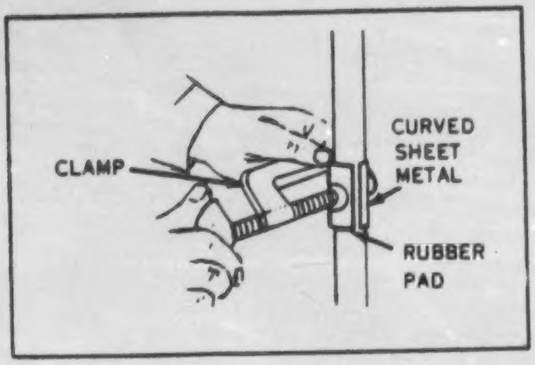

Figure 6-2. Repairing a hole in a pipe with a rubber pad, piece of sheet metal, and a clamp.

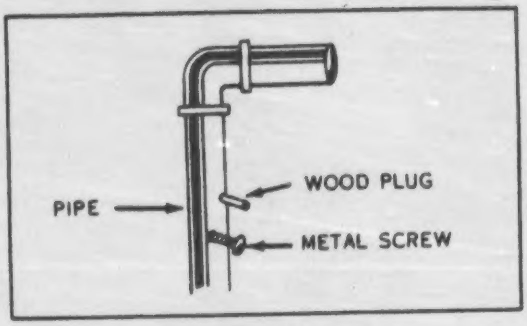

Figure 6-4. Repairing a hole in a pipe with a wood plug or sheet metal screw.

*c.* Rubber pad. Holes in pipe and fittings may also be repaired temporarily by covering the pipe with a rubber pad which is held in place by a sheet metal piece and a suitable clamp, as shown in figure 6-2.

*d.* Rubber tape. Another way to temporarily repair a small hole or crack in a pipe is by wrapping it with several layers of electrician's rubber tape, as shown in figure 6-3.

*e.* Wood plugs. Sometimes small holes are filled with wooden plugs. The plug is driven into the hole after it is drilled or reamed, as shown in figure 6-4. Hardwood is the best wood to use for making the plug. After the plug is driven into the hole, it will swell because of the absorption of moisture from within the pipe. This prevents the plug from being forced out of the pipe by water pressure.

*f.* Sheet metal screws. The use of sheet metal screws is an easy way to close holes in pipes, tanks, and similar equipment temporarily. To make a repair with a metal screw, place a small rubber washer on the screw and turn the screw into the hole with a screwdriver. The screw will form its own threads as it is screwed into the metal. Screw it into the wall of the pipe or tank far enough so that the rubber washer will make a seal.

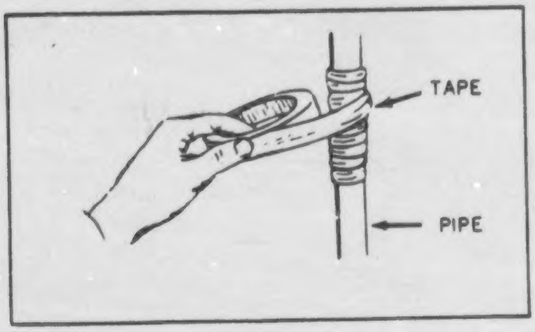

Figure 6-3. Repairing a hole in a pipe with electrician's tape.

*g.* Lever arrangement. Another improvised method of repairing a hole in a pipe is by a lever arrangement, as illustrated in figure 6-5. Pressure is applied over the rubber pad to stop the leak.

*h.* Pipe clamps. Emergency pipe clamps fastened around the pipe, shown in figure 6-6, is another way to repair pipe temporarily. The emergency clamp is a malleable iron cylinder halved, hinged along one side, and fitted with bolts on the other. A rubber gasket completes the clamp. To repair a pipe with an emergency clamp, select the right size clamp, place the gasket over the hole, and place the clamp around the pipe and over the gasket. Insert the bolts and turn the nuts down fingertight. Now, use a wrench to tighten the bolts completely. This clamp can be used either aboveground or underground. The emergency pipe clamp makes a dependable repair, but it is not used for a permanent repair in the Air Force.

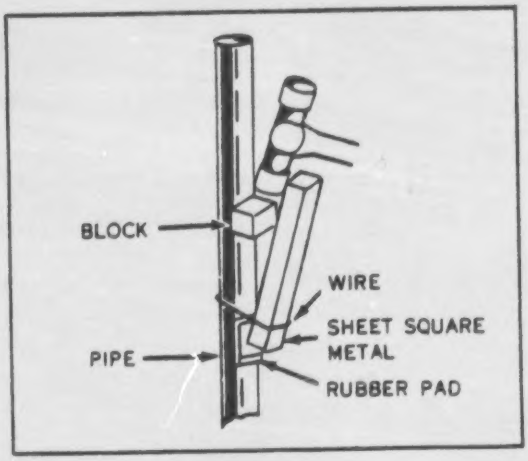

Figure 6-5. Repairing a hole in a pipe by a lever arrangement.

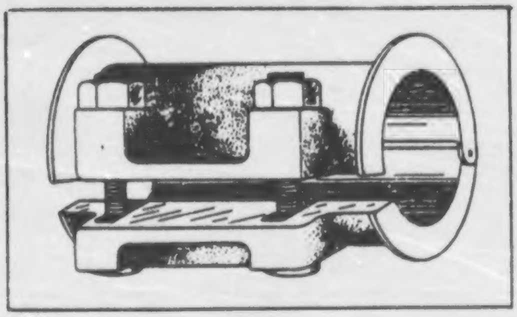

Figure 6-6. Emergency pipe clamp.

*Permanent pipe repairs.* Permanent pipe repairs should be made with pipes and fittings that are the same size and quality as the original installation. To make a permanent pipe repair, disconnect the pipe line at a convenient point, such as a union, and remove the damaged pipe. If there is no union, remove the damaged section of pipe by cutting it with a hacksaw or a regular pipe cutter. Cut the pipe at least 4 inches from a fitting, as shown in figure 6-7, A; then unscrew the ends. Cutting the pipe at least 4 inches from a fitting gives you working room to thread this short length and use it when you reassemble the pipe. The new section is made up of two lengths of pipe, one of which may be part of the old pipe and a union, which, when assembled, should equal the length of the old pipe, as shown in figure 6-7,B. A single length of pipe can be installed only when the old length of pipe is disconnected at a union. A similar procedure is followed when a branch line is cut into an existing line, except that a T-fitting is required between two new lengths, as illustrated in figure 6-7,C. This assembly must also be equal to the original length of pipe that was removed.

**Exercises (458):**

Choose the correct statement by placing a C in the appropriate spaces.

____ 1. A method of locating extremely slow leaks is to place a piece of white paper under the suspected leak.

____ 2. When buildings settle, strain is placed on piping systems.

____ 3. Once pipe and fittings are tight, slight unscrewing will not loosen the joint enough to cause a leak.

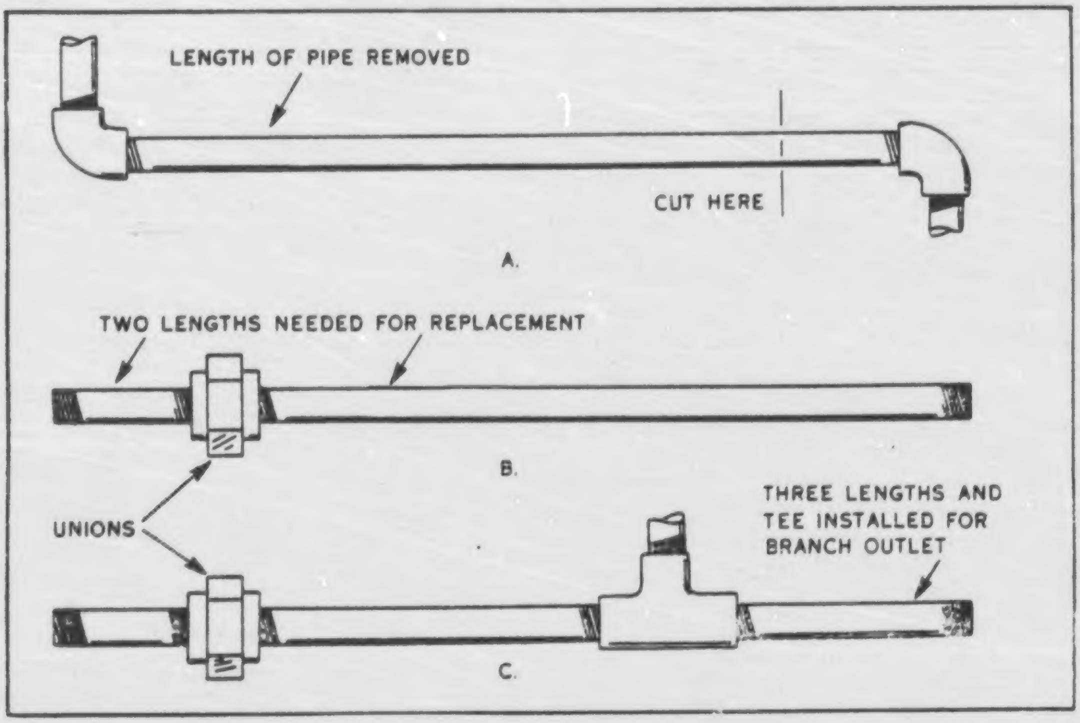
LENGTH OF PIPE REMOVED
CUT HERE
A.
TWO LENGTHS NEEDED FOR REPLACEMENT
B.
UNIONS
THREE LENGTHS AND TEE INSTALLED FOR BRANCH OUTLET
C.

Figure 6-7. Replacing pipe.

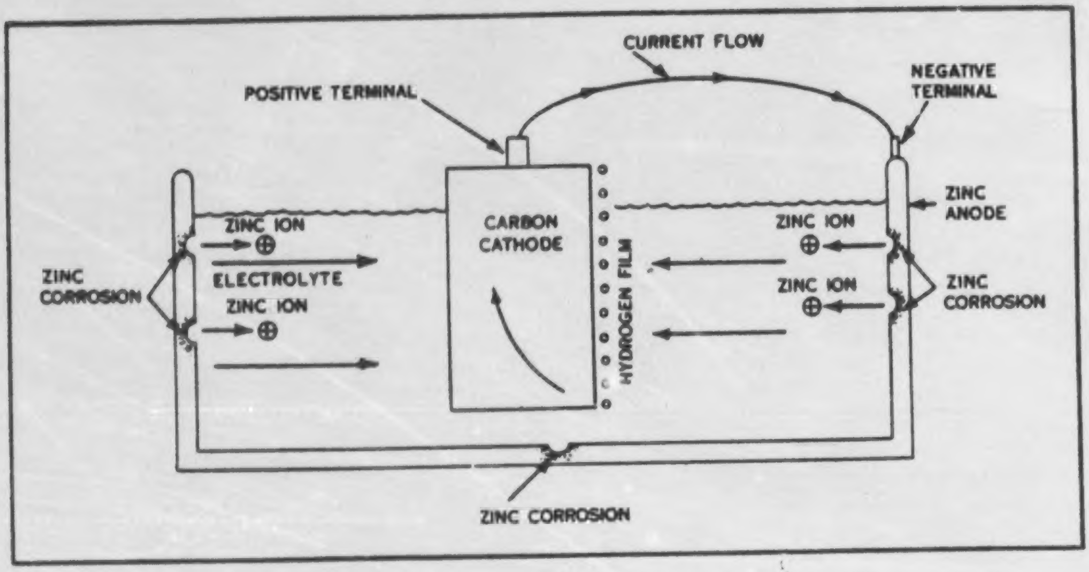

Figure 6-8. Galvanic cell showing internal galvanic action.

____ 4. Temporary repairs are intended to last an extended period of time.

____ 5. Hardwood is the best wood to use for making plugs for temporary pipe repairs.

____ 6. Permanent pipe repairs should be made with pipes and fittings that are the same quality as the original installation.

### 6-2. Corrosion Control

The deposit of scale and the action of corrosion on pipe lines, structures, and liquid- and gas-conveying equipment is a problem of vast importance and should be corrected as soon as possible. In our homes, scale clogs water heaters and pipes, while corrosion and its products eat away the metal walls of these units, causing leakage. The Air Force, as well as industry, has similar problems but they are much greater. Instead of maintaining a few feet of pipe as we do in our homes, the Air Force maintains miles and miles of pipe. Therefore, if the effect of corrosion on Air Force equipment can be decreased, a substantial saving can be made.

**459. Provided a list of statements and responses concerned with types of corrosion, match the responses to the statements.**

**Types of Corrosion.** Man has had corrosion problems to contend with ever since he started making articles out of metal. For thousands of years, the only fact known about corrosion was that it would affect some metals more than others. For example, iron, one of the most abundant and useful metals, corrodes very much; whereas metals such as gold, platinum, and silver corrode very little. In later years, men began to study corrosion to find out what caused it. As might be expected, many theories were proposed to explain corrosion and its causes. Among the many theories, the electrochemical theory is most generally accepted as an explanation of corrosion.

The electrochemical theory of corrosion is best explained by the action that takes place in a galvanic cell. A galvanic cell can be produced by placing two dissimilar metals in a suitable electrolyte, as shown in figure 6-8. The resulting electrochemical reaction develops a potential difference between these metals which causes one metal to be negative or anodic and the other metal to be positive or cathodic. In a dry cell battery, the zinc can is the anode and the carbon rod the cathode. Now, when an external electrical circuit is completed, current flows from the zinc case into the electrolyte, taking with it particles of zinc. This is an example of galvanic corrosion of the zinc case. It is this electrochemical action which illustrates the electrochemical theory.

Corrosion may be divided into several types, such as uniform corrosion, localized corrosion, and compositional corrosion. Each one of these will be explained in the following paragraphs.

*Uniform corrosion.* Uniform corrosion is caused by direct chemical attack. An example of this type of

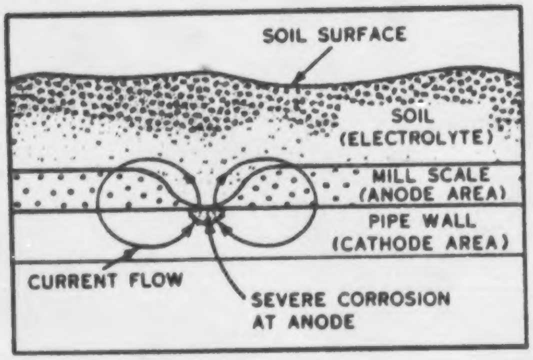

Figure 6-9. Corrosion due to mill scale.

corrosion is zinc exposed to hydrochloric acid. If you examine the surface of zinc in a solution of hydrochloric acid, you will find that the entire surface is corroding. Furthermore, if the zinc is left in the acid long enough, it will be dissolved by the acid.

*Localized corrosion.* Localized corrosion is caused by the electrolytic action of a galvanic cell. A local galvanic action is set up when there is a difference of potential between the areas on a metallic surface which is in an electrolyte. Localized corrosion may be in the form of pits, pockets, or cavities due to the deterioration or destruction of metal.

Localized corrosion may develop under a number of various conditions when different types of equipment are buried in the ground. Some examples of localized corrosion are discussed in the following paragraphs.

*a.* Corrosion due to mill scale. The mill scale embedded in the walls of iron pipe during its manufacture is one cause of pipe corrosion. It actually becomes the anodic area, the iron pipe the cathodic area, and the moist soil the electrolyte, as shown in figure 6-9. Current leaves the iron pipe wall, passes through the electrolytic soil to the mill scale and returns to the iron pipe. This electrochemical action causes severe pitting of the pipe metal at the anodic areas. Continued action of this type will eventually weaken the pipe to the extent of failure.

*b.* Corrosion due to cinders. Another type of corrosion occurs when iron pipe is laid in a cinder fill in direct contact with the cinders. The cinders and the iron pipe constitute the dissimilar metals. The pipe forms the anodic area, the cinders the cathodic area, and the highly ionized soil serves as the electrolyte. The current leaves the pipe through the soil to the cinders and returns to the pipe. Severe corrosion occurs at the points where the current leaves the pipe.

*c.* Corrosion due to dissimilarity of pipe surface. This type of galvanic corrosion occurs when there are bright or polished surfaces on some areas of the pipe walls in contact with suitable electrolytic soil. These bright surfaces become anodic to the remaining pipe surface. In highly ionized soil, the polished surfaces corrode at an accelerated rate, thus weakening the pipe at that point. These bright surfaces might have been caused by a pipe wrench which slipped and scarred or scratched the pipe when it was assembled. The cutting of threads on both ends of a coupling may expose shining surfaces that corrode easily. Corrosion in the threads will eventually cause holes in the pipe wall.

*d.* Corrosion due to different soil conditions. This is a general corrosion problem, especially prevalent in highly alkaline areas. Corrosion currents go from the pipe wall into compact soils and enter the pipe wall from light, sandy soils. The intensity of the corrosion currents and the resulting rate of corrosion at the anodic areas of the pipe are directly proportional to the conductivity of the soil.

*e.* Corrosion due to stray currents. Direct current circuits that pass in and out of an electrolyte usually cause stray currents, many of which are a direct cause of corrosion. This condition poses the greatest problem in the vicinity of electrical transportation systems, electrified coal mines, or manufacturing plants where the direct current distribution system requires a ground as a complete or partial circuit return. If a metallic structure such as a tank or pipe line is laid in such an area, a large galvanic cell is created. This makes a perfect setup for corrosion. Corrosion does not occur at the point where the current enters the structure, because it is cathodically protected. However, at the section where the current leaves the structure, severe stray current corrosion occurs. Over a period of a year, this type of corrosion has been known to displace as much as 20 pounds of pipe wall for every ampere of current.

*f.* Corrosion due to bacteria. Biological corrosion is another distinct type of corrosion which is caused by electrolytic or galvanic cell action. It is the deterioration of metals by corrosion processes which occur as either a direct or an indirect result of the metabolic activity of certain minute bacteria, particularly in water or soil environments. These organisms that cause bacterial corrosion are bacteria, slime, and fungi. Microbiological corrosive action in the soil is due to physical and chemical changes in the soil caused by the presence of these organisms. Some bacteria types are responsible for the production of active galvanic cells. These bacteria are mostly found in highly waterlogged, sulfate-bearing, blue clay soils. The bacteria concentration, as well as the corrosion rate, varies considerably with the different seasons of the year. Cast-iron and steel pipe are corroded mostly by sulfide production.

*Compositional corrosion.* Compositional corrosion alters the composition of metals. Some of the specific types of compositional corrosion are discussed in the following paragraphs.

*a*. Dezincification. This is a selective type of corrosion which occurs in copper and zinc alloys. When alloys of this kind (brasses) are exposed to this type of corrosion, the zinc dissolves out of the alloy and leaves only the copper. Some pipe fittings are made of brass, and dezincification attacks may weaken these fittings to the point of failure. The solution that dissolves the zinc may be impure water or oil that acts on an electrolyte.

*b*. Graphitization. Another type of compositional corrosion is graphitization or graphitic softening. It is a peculiar form of disintegration which attacks grey cast iron. Cast iron is an alloy made of iron and carbon, the carbon being in the form of graphite. When cast iron with such a composition is subjected to graphitization, the iron dissolves out and leaves only the graphite. This action leaves cast-iron pipes and other similar equipment weakened mechanically. However, after graphitization corrosion occurs, the graphite pipe may last for many years if it is not subjected to any mechanical forces or sudden pressures. The action of this type of corrosion is similar to dezincification.

*c*. Hydrogen embrittlement. Hydrogen embrittlement is a term applied to metal that becomes brittle because of the action of some form of corrosion which causes the formation of hydrogen on its surface. When hydrogen forms on the surface of steel, the action of the hydrogen may form blisters or actually embrittle the metal. It has been demonstrated that hydrogen liberated near the surface of steel in an electrolyte will diffuse into the metal quite rapidly. The hydrogen picked up by the steel is in an atomic state and causes the steel to become brittle.

When the production of atomic hydrogen on the surface of the metal stops, the hydrogen leaves the metal in a few days and the metal again regains its original ductility.

It has been found that carbon steels are affected by hydrogen embrittlement according to the hardness in the steel. The harder the metal, the greater is the susceptibility to hydrogen embrittlement. Hydrogen embrittlement in carbon steels is also increased by the presence of stresses.

Corrosion affects metals that are under stress. The action caused by stresses on a pipe line or structure is due to the shifting of the various rocks and soils of the earth. Usually a complete pipe line is not under stress: certain sections are under stress while adjacent sections are not. Because of these pressures and strains, localized electrochemical action takes place. The section of the pipe or structure under stress becomes anodic, whereas the unstressed sections become cathodic. In this way, the pipe under stress begins to corrode and weaken because of the action of corrosion.

*Corrosion caused by nonelectrolytes*. Nonelectrolytes are materials that will not conduct electricity. These materials include nonelectrolytic vapors, liquids, and bacterial organisms. Since they do not conduct electricity, they do not, in themselves, cause corrosion.

*a*. Nonelectrolytic gases and vapors. Nonelectrolytic gases and vapors usually must be subjected to high temperatures before corrosive action can take place. Hydrogen sulfide causes scaling of iron at temperatures from 1400° to 2000° F. High-chromium-alloy steels resist this type of corrosion best. The only remedy for this type of corrosion is to keep the gases away from the metal or use a metal that can resist corrosion.

High-carbon steels are attacked by hydrogen at temperatures above 750° F. This hydrogen combines with the carbon grains in the steel and causes the metal to weaken at the grain boundaries between the iron and carbon.

Oxygen will combine directly with most metals at high temperatures. The temperature at which oxygen will combine with the metals depends mostly upon the type of metal. In the process of cutting iron with an oxyacetylene torch, the oxygen combines with the iron.

*b*. Nonelectrolytic fluids. Nonelectrolytic fluids include such liquids as pure water, lubricating oils, fuel oils, alcohols, etc. These fluids do not cause corrosion, but corrosion does occur in storage tanks that contain these liquids and pipe lines that carry them. The corrosion is not caused by the nonelectrolytic liquids, but by the foreign products in them. For example, if impure water is introduced into an oil pipe line, the water will cause the inside of the pipe to corrode. The water collects on the inside of the pipe, because the pipe is usually cooler than the oil. In a storage tank, the water will settle to the bottom of the tank, because it is heavier than the oil, and will cause the bottom to corrode. Hydrogen sulfide and sulphur dioxide may also be introduced into the pipe line to add to the corrosiveness of the water that collects on the metal. The only way to prevent corrosion from this source is either to coat the inside of the pipe line and tanks with a protective film or to remove the water from them.

*c*. Bacterial organisms. Bacterial organisms may also cause microbiological corrosion. Colonies of bacteria that live close to the metal surface in stationary slimy deposits produce corrosive substances such as carbon dioxide, hydrogen sulphide, ammonia, and organic and inorganic acids. These corroding substances are found only in the locality of the colony and may be undetected in the surrounding water or soil. Bacteria which cause corrosion in this way need to produce only small amounts of corrosive products for localized attack. However, colonies of bacteria that do not produce corrosive products may act as a protective film around the metal, causing unequal distribution of electrical potential, which gives rise to local anodes and cathodes. In this way, the production of local cells will cause increased corrosive action.

Biological corrosion is extremely difficult to control, since the organisms are very resistant to normal methods of sterilization. Probably the most logical method to reduce microbiological corrosion is by the use of some barrier coating between the environment and the metal.

*Corrosion caused by electrolytes.* An electrolyte is any substance that conducts electricity. It conducts electricity because it contains ions which carry electrical charges, either negative or positive, and which move in electrical fields. Some of the more important electrolytes are discussed in the following paragraphs.

*a.* Atmospheric conditions. Corrosion due to atmospheric conditions is caused mainly by the water in the atmosphere. Pure water is a nonelectrolyte, but because it is a universal solvent, it is not found to be pure very often. Rain water is considered to be pure, but this is not true. As rain falls to the ground, it dissolves gases out of the atmosphere and becomes impure. For this reason, any water vapor in the atmosphere is also impure. If a piece of metal is exposed to atmospheric air, and the metal is cooler than the air, water vapor from the air will collect on the surface of the metal. The layer of water on the metal may be so thin that it cannot be seen, but there is enough of it, if impure, to start corrosion. In this case, when the gases dissolve into the water, the water becomes an electrolyte. When metal is exposed to an electrolyte, galvanic cells are produced on the surface of the metal, since there are impurities in it. Each one of these cells starts to act on the metal, causing corrosion by electrochemical action.

*b.* Water and water solutions. If metal is exposed to water or water solutions, corrosion is likely to occur if the water or metal is impure. If the water or metal is pure, corrosion probably will not occur; however, these conditions seldom exist in nature. Impurities in the water and metal produce galvanic cells which cause corrosion.

*c.* Chemical agents. Chemical agents such as acids and salts also cause corrosion. When these agents are present in the environment, direct chemical attack on metal is the result. For example, if a piece of zinc is exposed to hydrochloric acid, a definite chemical reaction takes place. The zinc and hydrochloric acid combine, producing zinc chloride and hydrogen. This action continues until the zinc is completely dissolved or the acid is too weak to act on the zinc. Corrosion in this case causes the zinc to dissolve.

Another example that may be used to illustrate corrosion through the use of a chemical agent is to place aluminum in a lye solution. The lye will pit (corrode) the aluminum as long as chemical action continues between the aluminum and lye.

**Exercises (459):**

Match the statements in column A to the responses in column B by placing the appropriate letter in the space provided.

| | *Column A* | | *Column B* |
|---|---|---|---|
| 1. ___ | Corrosion caused by the electrolytic action of a galvanic cell. | a. | Uniform corrosion |
| 2. ___ | Corrosion caused by direct chemical attack. | b. | Compositional corrosion |
| 3. ___ | Alters the composition of metals. | c. | Localized corrosion |
| 4. ___ | Causes scaling of iron at temperatures from 1400° to 2000° F | d. | An electrolyte |
| 5. ___ | Any substance that conducts electricity. | e. | Hydrogen sulfide |

**460. Select from a given list of materials those least likely to be affected by scale and corrosion.**

**Materials Least Likely To Be Affected by Scale and Corrosion.** Whenever the plumber installs various types of plumbing equipment in areas where corrosion is active, he should try to select equipment which is made of materials least affected by it. To prevent electrochemical action in plumbing equipment, it should be made of materials that are not affected by electrolysis. Plastic materials such as polyethylene polyester and polyvinyl chloride are not acted upon by corrosion. Glass is another material that is not acted on by corrosion. This is why hot water tanks are lined with glass. Other materials used for the manufacture of pipe which resist corrosion are vitrified clay, cement, fiber, asbestos, and rubber. Glass fibers reinforced with epoxy or polyester resins are also resistant to corrosion.

Dielectric bushings may be installed to stop electrolytic action in plumbing systems or wherever dissimilar metals are used. These bushings are made of nylon and are usually colored. They withstand pressures to 100 psi and temperatures up to 300° F. The bushings are usually placed in pipe systems as recommended by the manufacturer. Some of the metals least likely to be affected by corrosion are copper, brass, Monel, and stainless steel.

**Exercises (460):**

Select from the following list of materials those least likely to be affected by scale and corrosion by placing an X in the appropriate space(s).

___ 1. Glass pipe
___ 2. Plastic pipe
___ 3. Iron pipe
___ 4. Copper pipe
___ 5. Brass pipe

____ 6. Cast-iron pipe
____ 7. Monel pipe
____ 8. Steel pipe

**461. Given a list of coatings and wrappings used for corrosion protection and a list of jobs, match the coatings or wrappings to the appropriate job.**

**Coatings and Wrappings for Corrosion Protection.** Coatings and wrappings are commonly used to combat corrosion on exterior piping systems. There are many different types of coatings, such as asphalts, coal tars, plastics, mastics, greases, and cements. These coatings are considered to be insulating materials, but each is not effective in all environments. Each one was developed for a certain type of corrective environment.

*Asphalt coatings.* Asphalt base coatings are the most common type of protective coating used. They are produced from petroleum residue and natural sources. Asphalt base coatings can take considerable abrasion, impact, and temperature changes without creating a corrosive condition. However, they absorb a considerable amount of water and dissolve easily into a form of petroleum product.

*Coal tar coatings.* Coal tar coatings are commonly used on pipe lines. They possess continuity, hardness, adhesion, and corrosion resistance. Coal tar coatings are less expensive than asphalt coatings. They do not have a very good impact resistance, and a wide temperature change often causes the surface to crack.

*Paint coatings.* Some of the most important paint coatings are coal tar, asphalt, rubber, and vinyl.

Coal tar paints have the outstanding characteristics of low permeability and resistance to electrolytic reaction. They are not affected by the action of water. These paints are recommended for piers, marine installations, flood control structures, sewage disposal plants, and industrial concrete pipe lines.

Asphalt paints are weather resistant and durable against industrial fumes, condensation, and sunlight action. Because of their resistance against water solvency, they are used on steel tanks and concrete reservoirs.

Rubber base paints are very resistant to acids, alkalies, salts, alcohols, petroleum products, and inorganic oils. The resistance of these products makes them ideal for use on the inside of metallic and concrete storage tanks. If these structures are submerged in water or underground, a special form of this paint should be used because of condensation.

Vinyl type paint is one of the many synthetic resin base paints. These paints dry to a film that is tough, abrasionproof, and highly resistant to electrolysis. They are odorless, tasteless, nontoxic, and nonflammable. The film is especially resistant to oils, fats, waxes, alcohols, petroleums, solvents, formic acid, organic acids, ammonium hydroxides, and phenols. Because of these vinyl characteristics, it is very applicable for tanks, pipe lines, well heads, offshore drilling rigs, pipe-in oil industries, railroad hopper cars, dairy and brewery equipment, storage tanks, and concrete exposed to corrosive environments.

*Grease coatings.* Grease is another material used to form a protective coating on structures. It is usually made from a petroleum base and resembles paraffin or wax. Grease can be applied either hot or cold; however, it must be protected by some type of wrapping to keep the grease from being displaced or absorbed by the backfill soil when it is applied to underground surfaces.

*Concrete coatings.* Concrete coatings have been used with success when properly applied to pipe lines to be laid in highly corrosive soils, such as areas containing acid mine drainage or in brackish marshes. Well-mixed concrete, usually a mix of one part portland cement to two parts sand, may be applied to pipe lines. The thickness of the coating applied may be up to 2 inches. If the concrete is properly mixed and tamped around the pipe, it may last 40 years. However, concrete has a tendency to absorb moisture and crack, which in many ways limits its use. In fact, in places where the coating cracks, electrolysis immediately starts to corrode the metal. This corrosion can be partially prevented by painting the pipe with a bituminous primer before coating it.

*Metallic coatings.* Metallic coatings such as galvanizing (zinc coating) are very effective in protecting metallic structures or pipes against atmospheric type corrosion. This type of coating is ideal for cold water lines and metals exposed to normal atmospheric temperatures. However, metals such as iron corrode rapidly when used in high-temperature equipment. The reason for this is that at a critical temperature of approximately 140° F. iron becomes anodic to zinc. This results in the iron's becoming the sacrificial anode which corrodes readily.

*Plastic wrapping.* Plastic tapes for wrapping come in rolls. They may be procured in various widths to suit the user. The tape is wrapped around the pipes before they are laid in the trench. The wrappings are applied by a simple device that is clamped on the pipe and turned by the plumber. Pipe joints are wrapped after the pipes are laid in the trench.

**Exercises (461):**

Match the coatings and wrappings in column B to the list of jobs in column A by placing the letter(s) in the appropriate blank(s).

| *Column A* | *Column B* |
|---|---|
| ____ 1. Cold water pipes exposed to normal atmospheric temperatures. | a. Vinyl type paint |
| ____ 2. Inside of a concrete storage tank. | b. Metallic coatings |
| ____ 3. Brewery equipment. | c. Rubber base paint |

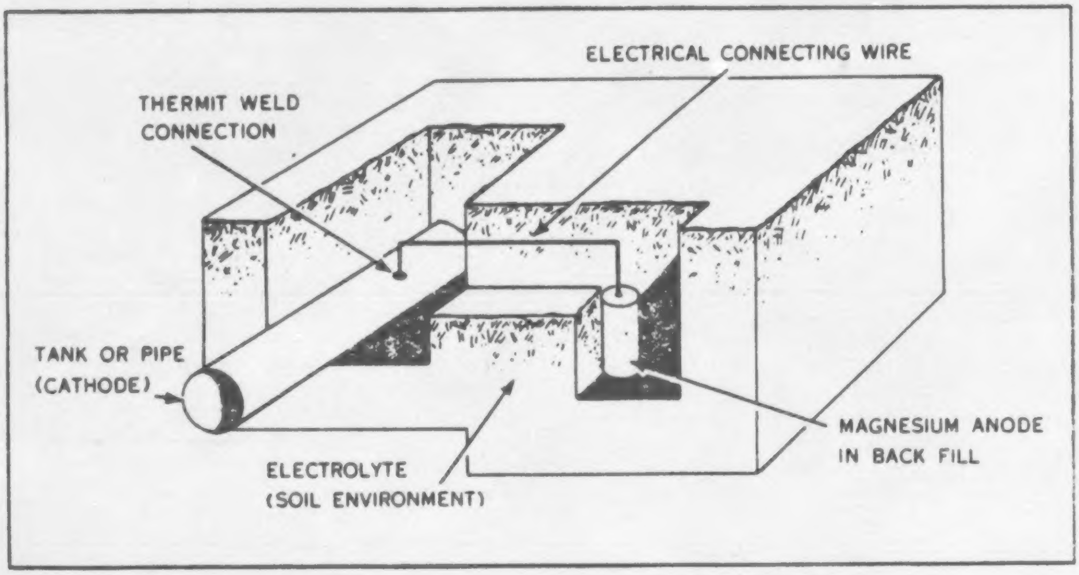
ELECTRICAL CONNECTING WIRE
THERMIT WELD CONNECTION
TANK OR PIPE (CATHODE)
MAGNESIUM ANODE IN BACK FILL
ELECTROLYTE (SOIL ENVIRONMENT)

Figure 6-10. Galvanic cathodic protection.

**462. Given a list of statements relating to galvanic cathodic protection, identify the true statements.**

**Galvanic Cathodic Protection.** Galvanic cathodic protection is a method used to protect metal structures from the action of corrosion. As explained before, galvanic cell corrosion is the major contributing factor to the deterioration of metal by electrochemical reaction. The area of a structure that corrodes is the anode or positive side of the cell. Corrosion occurs when the positive electric current leaves the metal and enters the electrolyte. Galvanic cathodic protection is designed to stop this positive current flow. When the current is stopped, the corrosive action stops and the anodes disappear. This type of protection depends upon the neutralization of the corroding current and the polarization of the cathode metal areas.

Galvanic cathodic protection is a means of reducing or preventing the corrosion of a metal surface by the use of sacrificial anodes or impressed currents. When sacrificial anodes are used, it is known as the galvanic anode method. If impressed currents are used, it is known as the impressed current method. These two methods can be used separately or in conjunction with each other, depending upon the corrosive characteristics of the electrolyte surrounding the structure.

*Galvanic anode method.* The galvanic anode method of cathodic protection uses an electrode referred to as a sacrificial anode that corrodes to protect a structure. This sacrificial anode is electrically connected to and placed in the same electrolytic area of the structure. The anode used to protect iron or steel structures should be made of magnesium or zinc so that it will produce a sufficient potential difference to cause the structure to become a cathode. The action of this type of galvanic protection causes the electric current to flow from the sacrificial anode through the electrolyte to the structure to be protected. The electrical connection between the two metals completes the circuit and allows the current to return to the corroding metal. The sacrificial anode becomes the anode of the established dissimilar metal galvanic cell, and the structure to be protected becomes the cathode. The current from the sacrificial anode is intense enough to oppose or prevent the positive current from leaving the anodes in the structure to be protected. These structure anodes are then suppressed, and the metal in the structure becomes a cathode. The prevention of these positive currents from the anodic areas in the structure reduces the corrosion rate to almost zero.

Galvanic cathodic protection is used in areas where the corrosion rate is low and the electric power is not readily available. A typical example of galvanic cathodic protection is shown in figure 6-10.

*Impressed current method.* The impressed current method of cathodic protection is designed to protect large metal structures located in corrosive areas. With this method of protection a source of alternating current is required. In addition, a rectifier is needed to obtain the required direct-current potential.

The basic principle of the impressed current method is merely the application of the galvanic cell reaction. The component parts of this method are the cathode, which is the metal structure to be protected; the anode, made of suitable anodic material; the electrolyte or ground, which is the ionized corrosive material; and the rectifier and various connections which serve to complete the electrical circuit. The operation of this method depends on the rectifier, which forces direct current from the anode through the electrolyte (ground) to the metal structure to be protected. This method causes the metal structure to be the cathode, suppresses the anodic currents from it, and in turn prevents corrosion of the structure. An impressed current method of cathodic protection is illustrated in figure 6-11.

**Exercises (462):**

Identify the true statements by placing a T in the appropriate spaces.

____ 1. Corrosion occurs when the positive electric current leaves the metal and enters the electrolyte.

____ 2. When sacrificial anodes are used, it is known as the galvanic anode method.

____ 3. The anode used to protect iron or steel structures should be made of copper.

____ 4. The impressed current method is designed to protect small metal structures in noncorrosive areas.

____ 5. The basic principle of the impressed current method is merely the application of the galvanic cell reaction.

____ 6. The operation of an impressed current system depends upon the rectifier.

**463. Provided a list of field test equipment for cathodic protection and related uses, match the field test equipment to its particular use.**

**Field Test Equipment for Cathodic Protection.** The items of field test equipment that the plumber uses to make tests when installing, operating, and maintaining cathodic protection systems are the volt-millivoltmeter, multicombination meter, resistivity instrument, buried pipe locator, and protective coating leak detector. This equipment is discussed in the following paragraphs.

*Volt-millivoltmeter.* In corrosion and cathodic protection testing in the field, it is necessary to measure the potential of the structure being investigated as compared to the earth along the structure and to other metallic structures. It is also necessary to measure the potential of rectifiers, batteries, galvanic anodes, and sometimes potentials along the earth's surface to determine the distance being protected. The potentials may vary from millivolts to 20 volts or more. Various types of voltmeters are used for this purpose. One of these

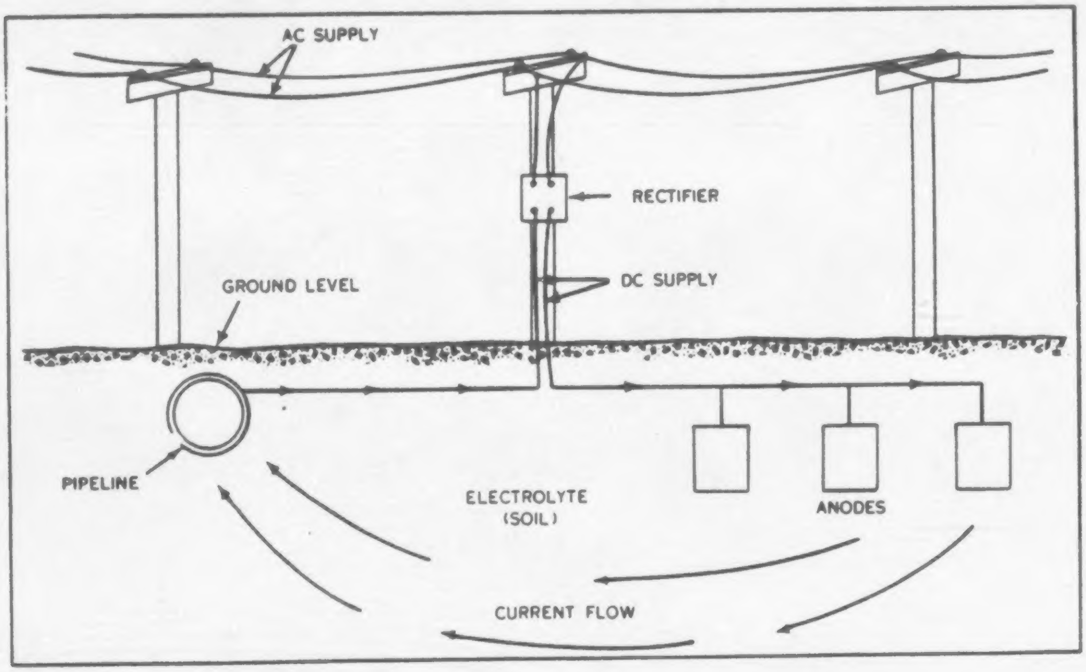

Figure 6-11. Impressed current method of cathodic protection.

instruments is the volt-millivoltmeter. It is a recording instrument designed with a chart that makes one revolution in 24 hours. The instrument will record the variations in potential and reveal the electrolytic conditions around a structure.

*Multicombination meter.* The multicombination meter is used quite often in cathodic protection work. It is designed as a combination unit and actually consists of more than one instrument. The meter can be used as a high-resistance voltmeter, an ammeter and milliammeter, a low-resistance voltmeter and millivoltmeter, and a potentiometer voltmeter.

The multicombination meter may be used to measure galvanic anode current between an anode and structure, galvanic current between structures, and potentials as with other types of voltmeters and millivoltmeters.

*Resistivity instruments.* Resistivity measuring instruments are units used to test the corrosive action of a soil. Tests regarding soil corrosivity are necessary when designing cathodic protection systems. Information from these tests is used to locate the most corrosive areas where a pipe line is to be laid and the most corrosive areas of an existing pipe line. It is also used to decide the location for anode beds.

One of the simplest methods for making a resistivity test is to use a single probe resistivity meter. It consists of a probe with two electrodes, an indicating instrument, switches, and the required wiring. To use this instrument, the probe is inserted into the ground and current is applied to it. The indicating instrument gives a reading which indicates the corrosiveness of the soil.

*Buried pipe locator.* In the field of cathodic protection work, it is necessary to locate pipes in order to locate interferences in the cathodic protection system. An electronic pipe locator is used for this purpose. The main components of the locator are the directional transmitter and the directional receiver. Each one of these units is carried by an operator. The operators are usually about 30 feet apart. During actual operation the transmitter sends out signals which travel along the pipe line. The receiver, in turn, picks up these signals in varying intensities, depending on the distance the operators are from the pipe. When both operators are directly over the pipe, a maximum response is obtained in the phones and on the visual meter of the receiver. Most pipe can be located easily and accurately in this manner.

*Protective coating leak detector.* A protective coating leak detector, referred to as a "holiday director," is used to detect the imperfections (holidays) in pipe coatings. The holiday leak detector is an instrument which operates on an electric current. When it is being moved along a pipe that is covered by a coating or wrapping, a completed circuit between it and the pipe reveals a holiday and causes a bell to ring, or a bulb to light, or a buzzer to sound.

**Exercises (463):**

Match the field test equipment in column B to its particular use stated in column A by placing the letters in column B in the appropriate spaces in column A.

| | *Column A* | *Column B* |
|---|---|---|
| ____ 1. | Used to measure galvanic anode current between an anode and structure. | a. Volt-millivoltmeter |
| ____ 2. | Used to detect the imperfections in pipe coverings. | b. Resistivity instrument |
| ____ 3. | Used to test the corrosive action of a soil. | c. Multicombination meter |
| ____ 4. | Used to record the variations in potential and reveal the electrolytic conditions around a structure. | d. Holiday detector |

**464. Select the true statements pertaining to maintenance of anode systems.**

**Maintenance of Anode Systems.** The anode system of cathodic protection requires very little maintenance because it does not have a power source and does not have to be regulated.

Magnesium and zinc anodes used in the anode system sometimes suffer local or self corrosion which reduces their efficiency. When their efficiency drops to a minimum, they must be replaced. Anode life varies from 5 to 30 years, depending upon the type of anode used. It is conservative to figure that about 17 pounds of magnesium or 25 pounds of zinc are wasted away by electrolysis from an anode per ampere year. Test stations should be installed in the anode system so that the effectiveness of the cathodic protection can be determined.

**Exercises (464):**

Select the true statements by placing a T in the correct spaces.

____ 1. Anode life varies from 5 to 30 years.
____ 2. The anode system of cathodic protection requires constant maintenance.
____ 3. Test stations should be installed in anode systems.
____ 4. It is conservative to figure that about 17 pounds of magnesium waste away by electrolysis per ampere year.

**465. From a given list of statements concerning maintenance of impressed current systems, identify those that are correct.**

**Maintenance of Impressed Current Systems.** The impressed system of cathodic protection requires considerably more maintenance than the anode system. This is because an electrical current is used for the operation of the system. The current may come from any ac source. Wind-driven generators can be used to furnish the alternating current when it is not readily available. The transformer rectifier used in the system requires much less maintenance and servicing than other sources of current. However, systematic maintenance procedures must be used to keep these units in operating condition.

The transformer rectifier set consists of two units, a transformer and rectifier. The transformer is used to step the high voltage down to a value of 12 to 40 volts, and the rectifier is used to change alternating current to direct current. Connections on this unit must be kept tight.

The materials most often used for anodes with impressed current are aluminum, high silicon, cast iron, and graphite. Scrap iron and steel may be used for anodes, since they waste away at a rate of 20 pounds per ampere year. Anodes must be replaced when they are totally wasted away.

Insulated wire that resists electrolytic action must be used to make the connections between the anodes and the structures to be protected. The insulation on existing current-carrying lines should be checked, and if deterioration is evident, the wires should be replaced. Overhead electrical lines should be checked also to see that they are securely fastened to the poles and that the connections are tight.

**Exercises (465):**

Identify the correct statements by placing an X in the appropriate space(s).

____ 1. The impressed current system requires considerably less maintenance than the anode system.

____ 2. The transformer rectifier set consists of two units, a transformer and a rectifier.

____ 3. The materials most often used for anodes with impressed current are aluminum, high silicon, cast iron, and graphite.

____ 4. Insulated wire that resists electrolytic action must be used to make the connections between the anodes and the structures to be protected.

## CHAPTER 7

# Fire Protection and Lawn Sprinkler Systems

THE INSTALLATION of fire protection systems is one of vital importance. Construction of fire control systems is within the scope of responsibility of the plumbing shop.

The Air Force has several thousand buildings which require fire protection; so you see, adequate knowledge of the supply and distribution systems for fire protection is necessary for all concerned. Without proper operation and maintenance of these systems, the entire effectiveness of fire protection is nullified.

This chapter covers exterior fire protection systems, inspection and maintenance of fire hydrants, interior fire protection systems, maintenance of interior fire protection systems, and lawn sprinkler systems.

### 7-1. Fire Protection System

Water is the most practical extinguishing agent for ordinary structural fires. It absorbs heat rapidly and with greater capacity than most other agents used for fire extinguishment.

**466. Given a list of statements and responses relating to exterior fire protection systems, match the responses to the statements.**

**Exterior Fire Protection System.** Fire hydrants are an important part of the installation fire protection system and must be kept in good working order at all times.

*Fire Hydrants.* Fire hydrants are manufactured in several different types and models. However, the three most important types are the flush, traffic, and standard.

The flush type hydrant, illustrated in figure 7-1, is normally installed in holes, below ground level, with the cover at ground level. This type of hydrant is ideal for areas where there is heavy foot or vehicle traffic. It is also used where above-ground hydrants would distract from the appearance of the surroundings. You will find these hydrants installed in such areas as airports, narrow streets, and sidewalks.

The traffic model fire hydrant, illustrated in figure 7-2, is designed to break away when hit by a vehicle. This feature minimizes damage to both the vehicle and its occupants. This hydrant will break away without loss of water.

These hydrants have breakable bolts and a breakable coupling (on the stem) at the ground level. In case of a collision, the top part of the hydrant will

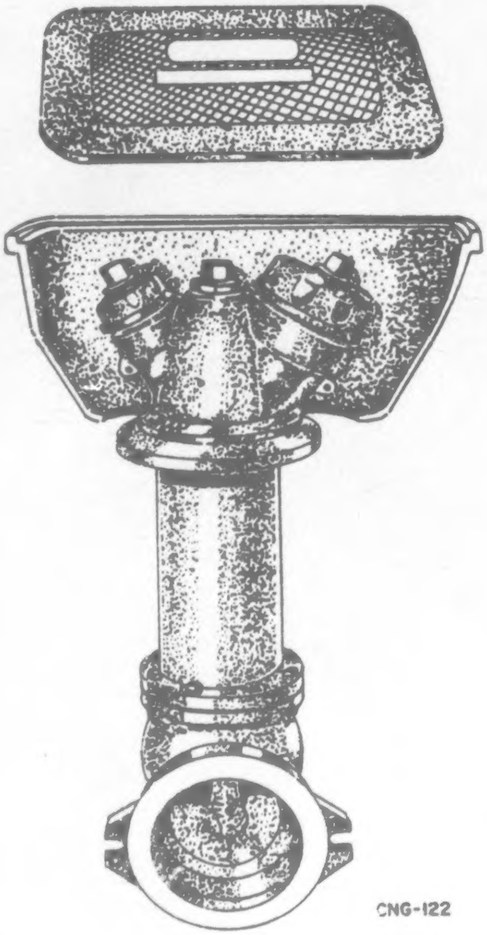

Figure 7-1 Flush type fire hydrant

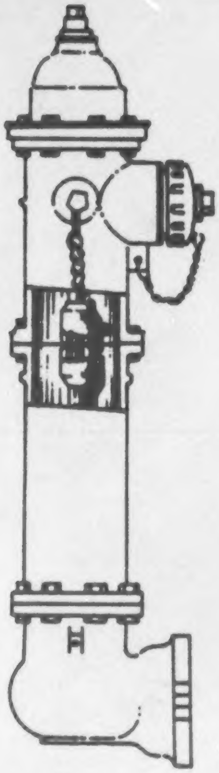

Figure 7-2. Traffic type fire hydrant.

break away with minimum damage to the hydrant or vehicle. The main water valve remains seated because it is held closed by water pressure. A broken hydrant can be repaired easily and quickly by using a safety flange repair kit. (See fig. 7-3.) This kit consists of eight breakaway bolts, a breakable coupling, and a standpipe gasket.

The standard type of fire hydrant, shown in figure 7-4, is similar to the traffic model with the exception of the breakaway feature. The other component parts are the same and are interchangeable.

Most fire hydrants have one pumper nozzle and two hose nozzles. The pumper nozzle is 4 inches in diameter and the hose nozzles are 2½ inches. The nozzles should face in the direction that is the most convenient for use.

A fire hydrant is a very simple fixture. However, it does consist of over 40 different parts. A cutaway fire hydrant with the name of the parts is illustrated in figure 7-5.

*Location of fire hydrants.* Hydrants are usually placed about 400 feet apart in housing areas so that every building can be reached from two hydrants with not more than 300 feet of hose. They are located about 300 feet apart in warehouse and airfield-hangar areas. The hydrant should be at least 6 feet from paved road surfaces, at least 3 feet from any obstruction, and not directly in front of homes, entrances and drives.

*Installation of fire hydrants.* As a plumber, you may be called upon to install a fire hydrant. During the installation procedures, you should consider the following factors:

(1) The lowest outlet should be at least 18 inches above the ground.

(2) The highest operating nut must not be more than 48 inches above the ground.

(3) The water main feeding the hydrant must be 6 inches in diameter or larger.

(4) An isolation valve should be installed between the water main and the hydrant (see fig. 7-6).

(5) The water line to the hydrant must be buried deep enough to eliminate the possibility of freezing.

(6) The drain hole must be open.

(7) The hydrant should be braced with a kick block opposite the water entrance. This is to keep the pressure from "blowing" the hydrant off the pipe. The hydrant is braced by using concrete between the hydrant and solid ground.

(8) If the soil is sandy and unstable, attach the hydrant to the water main with bridle rods and clamps. The rods should be at least 3/4 inch in diameter and coated with an acid-resistant paint.

(9) After the hydrant has been connected, pack at least 7 cubic feet of crushed rocks around the base of the hydrant. This is to insure thorough draining of the hydrant.

(10) The earth should be replaced in layers 6 inches thick or less. Each layer should be tamped thoroughly before adding the next layer.

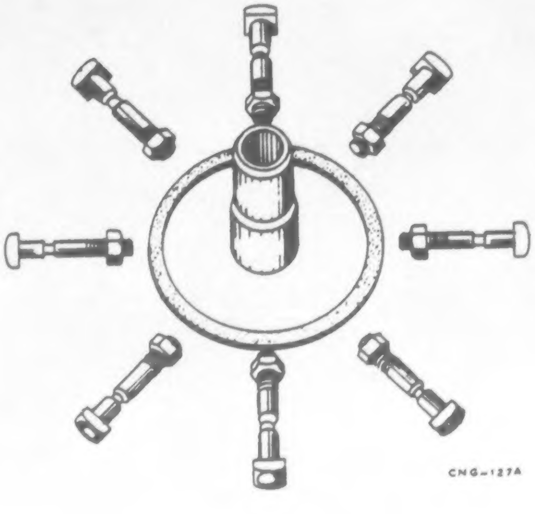

Figure 7-3. Safety flange repair kit.

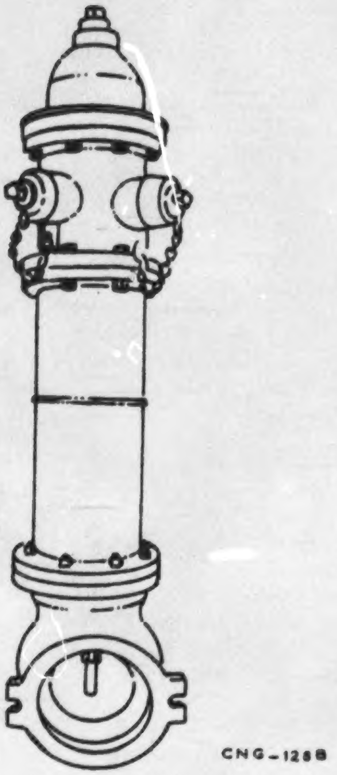

Figure 7-4. Standard type fire hydrant.

*Extending the height of a hydrant.* Occasionally, it may become necessary to raise the height of a fire hydrant. This can be easily accomplished by the use of an extension kit. (See fig. 7-7.) The extension kit consists of an extension barrel, an extension stem and the necessary bolts, nuts, and gaskets. Extension kits come in increments from 6 inches to 4 feet.

**Exercises (466):**

Match the statements in column A top the responses in column B by placing the appropriate letter(s) in the spaces provided.

| *Column A* | *Column B* |
|---|---|
| 1. ___ Diameter of the pumper nozzle. | a. Flush |
| | b. 6 feet |
| 2. ___ Diameter of the hose nozzle. | c. 4 inches |
| | d. 3 feet |
| 3. ___ Type of hydrant used at airports. | e. 2½ inches |
| | f. 18 inches |
| 4. ___ Type of hydrant used where there is a possibility of collision. | g. 48 inches |
| | h. Traffic |

*Column A*

5. ___ The minimum distance a fire hydrant should be from a paved road.

6. ___ The minimum distance a fire hydrant should be away from the nearest obstruction.

7. ___ The maximum distance the operating nut of a hydrant can be above ground level.

8. ___ The minimum distance the lowest opening of a hydrant can be above ground level.

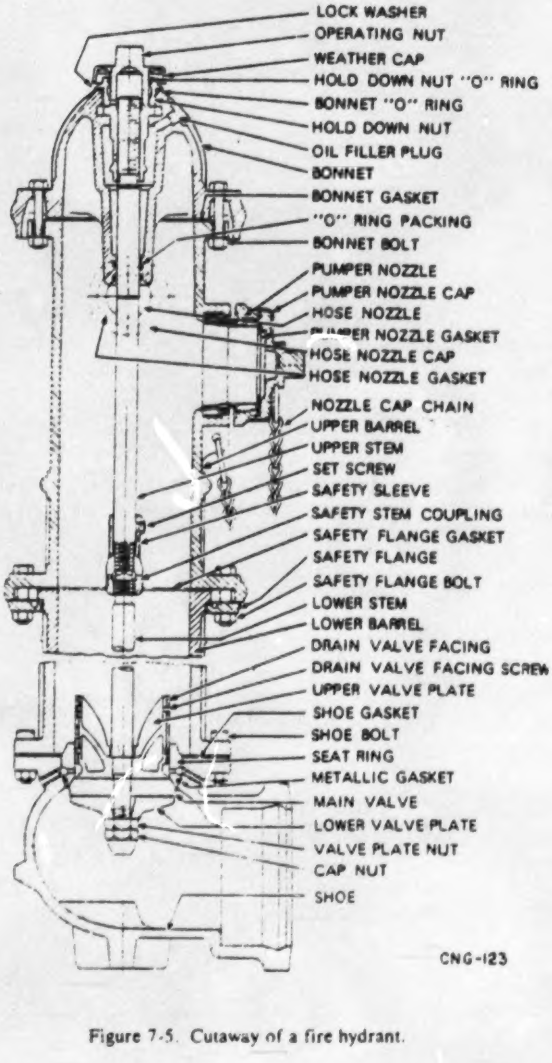
LOCK WASHER
OPERATING NUT
WEATHER CAP
HOLD DOWN NUT "O" RING
BONNET "O" RING
HOLD DOWN NUT
OIL FILLER PLUG
BONNET
BONNET GASKET
"O" RING PACKING
BONNET BOLT
PUMPER NOZZLE
PUMPER NOZZLE CAP
HOSE NOZZLE
PUMPER NOZZLE GASKET
HOSE NOZZLE CAP
HOSE NOZZLE GASKET
NOZZLE CAP CHAIN
UPPER BARREL
UPPER STEM
SET SCREW
SAFETY SLEEVE
SAFETY STEM COUPLING
SAFETY FLANGE GASKET
SAFETY FLANGE
SAFETY FLANGE BOLT
LOWER STEM
LOWER BARREL
DRAIN VALVE FACING
DRAIN VALVE FACING SCREW
UPPER VALVE PLATE
SHOE GASKET
SHOE BOLT
SEAT RING
METALLIC GASKET
MAIN VALVE
LOWER VALVE PLATE
VALVE PLATE NUT
CAP NUT
SHOE
CNG-123

Figure 7-5. Cutaway of a fire hydrant.

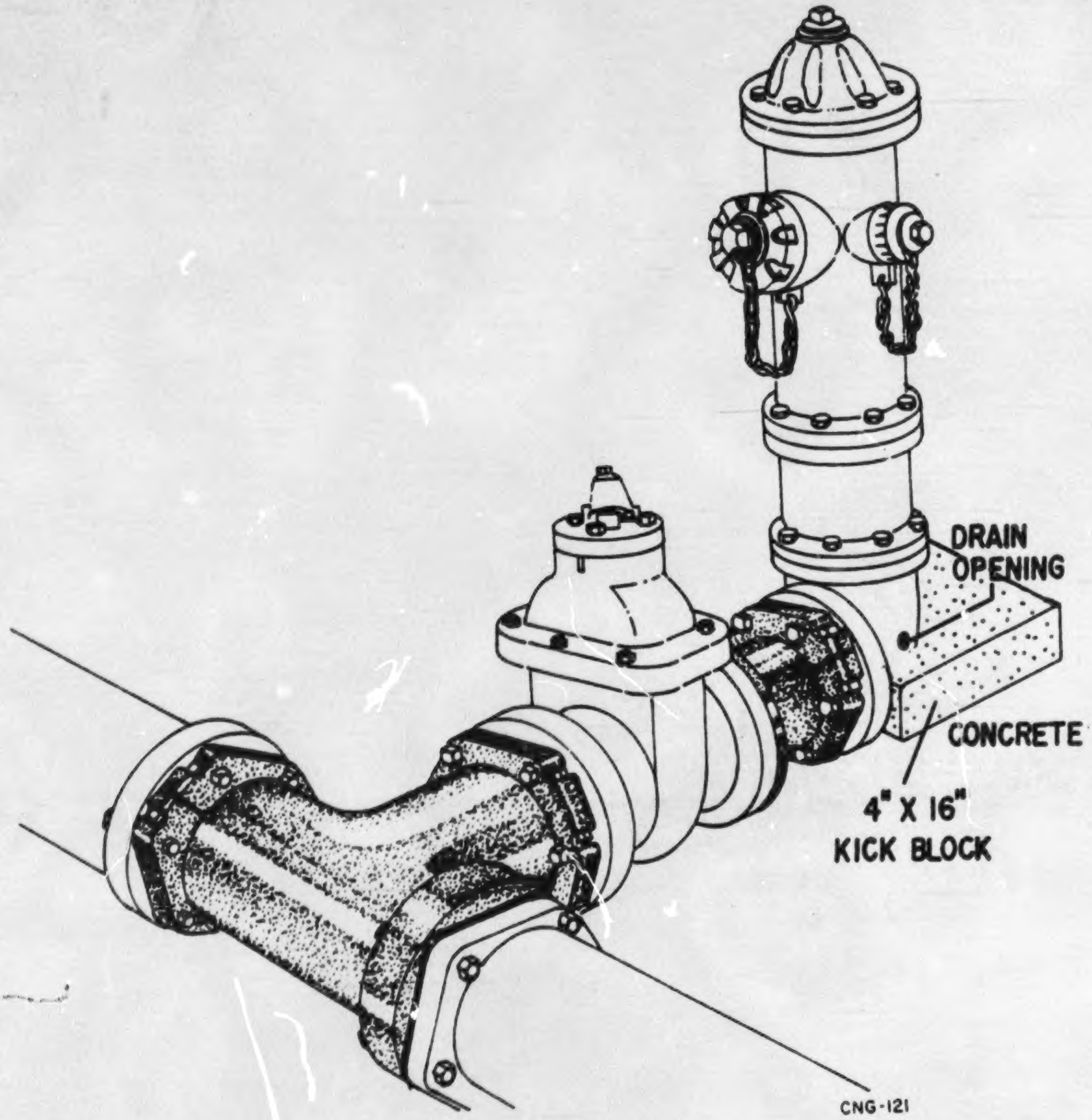

Figure 7-6. Isolation valve.

**467. Select the correct items from a list pertaining to inspection and maintenance of fire hydrants.**

**Inspection and Maintenance of Fire Hydrants.** Inspection and maintenance of fire hydrants is performed on an annual basis. Each base has a recurring maintenance program which identifies the time to perform the inspection and what maintenance is to be performed.

The variety of makes and models of fire hydrants necessitates listing data for each different type or make of hydrants on base. Descriptive matter and operating and repair instructions should be obtained from manufacturers and filed for quick reference.

*Inspection of hydrants.* Inspection of fire hydrants should be performed in peak flow periods, usually in the summer months. You should start your inspection at the fire hydrant nearest the beginning of the base water supply source, and continue through the system until all hydrants and valves have been inspected. A record should be maintained on each fire hydrant. The records should be kept on AF Form 995, Gate Valve/Hydrant Record, showing pertinent physical data, including a sketch or drawing referencing the location of the hydrant.

When inspecting fire hydrants, you should locate the nearest valve to the hydrant. Most hydrants have an isolation valve installed approximately 3 to 5 feet from the base of the hydrant. This is to allow you to turn off only the hydrant being worked on instead of a block or more of the water main. After you find the valve, you should tighten the hose connection caps on the hydrant. Next, you should turn the hydrant all the way on. With the hydrant full of water and under main pressure, you can inspect for any leaks and record them for maintenance. Check all movable parts for wear: for instance, the operating nut, the caps for the nozzles, the thread on the nozzles, etc.

The plumbing shop, in conjunction with the fire department, should make a velocity pressure check and a residual pressure check during the inspection of hydrants to determine the capabilities of the system for fire protection. These pressure checks should be made in accordance with AF Manual 85-13.

*Maintenance of hydrants.* Hydrants can be maintained by replacing all worn or malfunctioning parts and seats through the top of the hydrant. Many hydrants require special wrenches or fittings to withdraw the lower parts. Proper tools should be obtained for every type of hydrant on the installation.

Recurring maintenance usually consists of lubricating the operating nut and replacing the operating nut, hose nozzles with bad threads, nozzle caps, cap chains, bonnet, and flange gaskets. This type of maintenance can usually be performed without turning off the isolation valve, because the main water pressure will keep the hydrant valve closed.

Other maintenance to the hydrants will require turning the isolation valve off. Any maintenance involving those parts retained in the shoe of the hydrant will require that the water be turned off.

If the hydrant barrel does not drain properly after the hydrant has been turned off, either the drain hole is plugged or the main valve is leaking. You can determine if it is the main valve by placing your ear against the operating nut and listening for the sound of water rushing between the main valve and ring seat. If you find that this is the problem, you should remove the main valve and replace it. Usually the ring set, its gaskets, and the drain valve facing need to be replaced at the same time.

If you find that the drain valve is plugged, the hydrant will have to be dug up and the stoppage removed. You will find that the stoppage is usually dirt

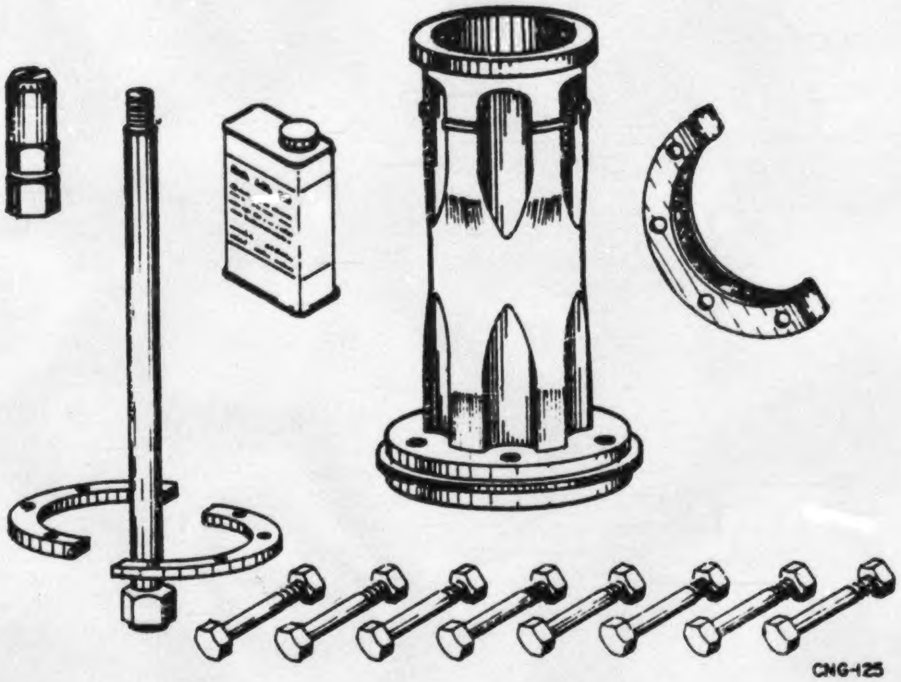

Figure 7-7. Hydrant extension kit

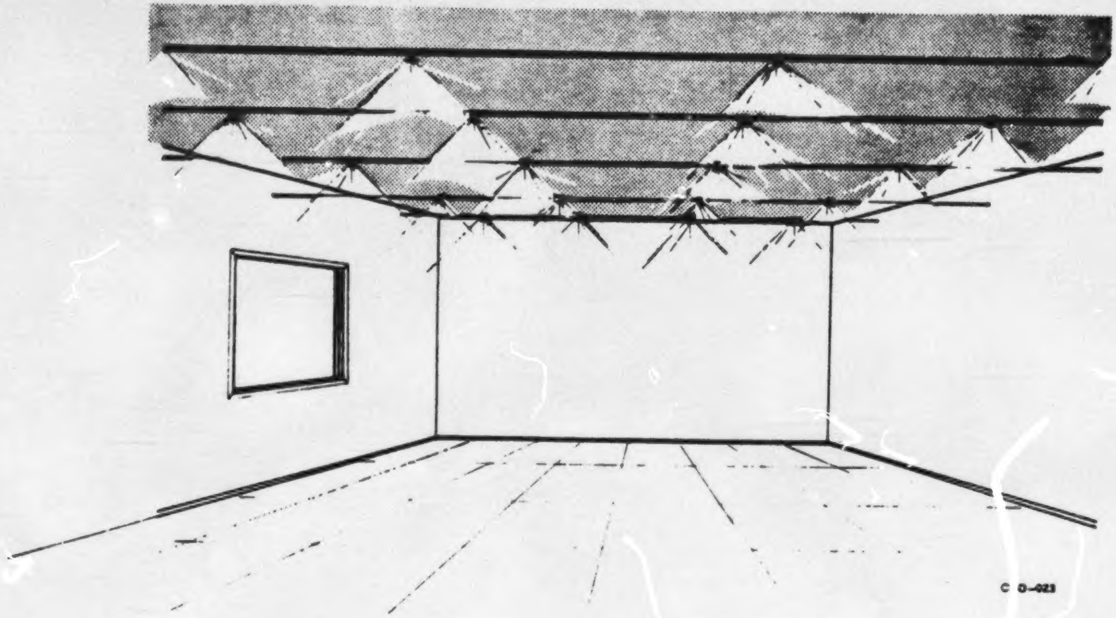

Figure 7-8. Typical building fire sprinkler system.

and rust. After the drain has been opened and you start to back fill, make sure that crushed gravel is placed in the hole to a point above the drain opening; then finish filling the rest of the hole with earth in 6-inch layers and tamp each layer.

**Exercises (467):**

Select the correct items by placing an X in the spaces provided for those that are correct.

1. ____ Inspection of fire hydrants should be performed during peak flow periods.
2. ____ Valve and hydrant records should be maintained on AF Form 995.
3. ____ Velocity and residual pressure checks should be made in accordance with AFM 85-14.
4. ____ You can determine if the main hydrant valve is leaking by watching the water fall in the hydrant barrel.
5. ____ Usually the ring seat, its gaskets, and the drain valve facing need to be replaced at the same time you replace the main valve.

**468. From a selected list of statements concerning interior fire protection systems, choose those that are correct.**

**Interior Fire Protection Systems.** The requirements for proper fire protection on an Air Force base consists of much more than the distribution of fire extinguishers throughout buildings and the moving of a few firetrucks. You will also find fire sprinkler systems inside many of the buildings on a base. A sprinkler system automatically spreads water over a burning part or floor area in a building. It will extinguish the fire completely or hold it in check until the fire department arrives. These systems are automatically put into operation by the breaking of fusible links or the contact of heat-activated devices. In addition, some systems may have manual controls (see fig. 7-8).

The type of system to be installed in a building is selected during construction planning. Otherwise, the system must be installed or modified on existing buildings. This is more expensive. In either case, the system should be selected and installed with the following factors in mind:

- Type of building (size, construction, material).
- Occupancy (contents and hazards).
- Heating facilities and location.
- Available water supply.

*The wet pipe system.* The wet pipe system is filled with water and connected to an adequate water supply and the sprinkler heads are sealed. Heat applied to the fused head causes the sprinkler heads to discharge water on the area below them. A waterflow tong on an alarm valve indicates waterflow and alarms.

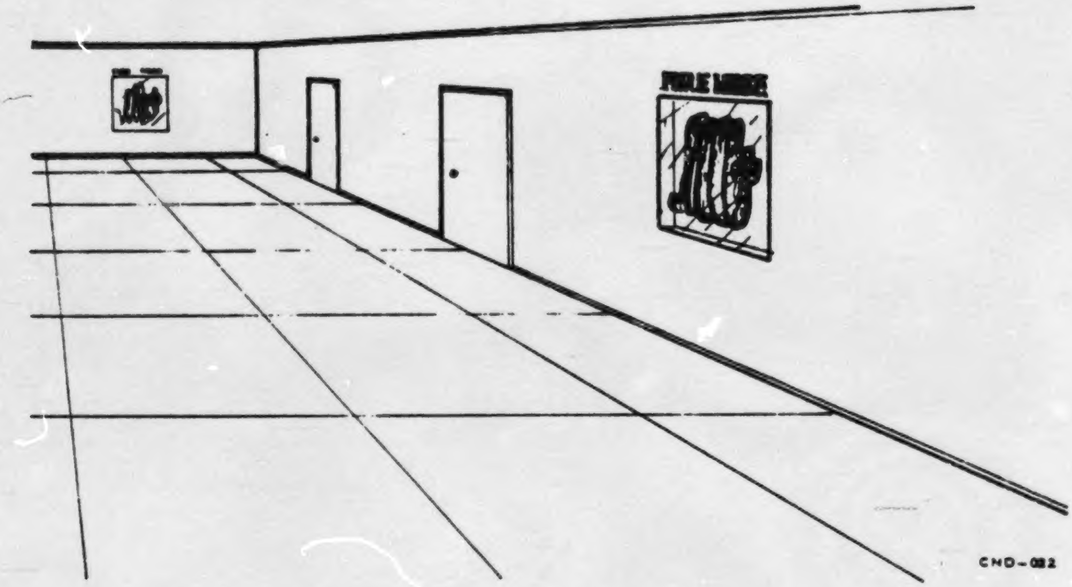

Figure 7-9. Standpipe in building.

This is the simplest and least expensive system. It is suited for locations where freezing temperatures are of no concern.

*The dry pipe system.* A standard dry pipe system is a modified version of the wet pipe system. It has a dry pipe valve which is kept closed by air pressure—instead of water pressure—in the piping. Since there is not any water in the piping, there is not any danger of frozen lines. An installed air compressor is used to provide the pressure to hold the valve (sometimes called the differential clapper) closed.

When the fuse in the sealed head melts and separates, the air pressure is released. The water pressure then opens the dry pipe valve, and water flows through the piping and is distributed on the fire.

Delays in action because of the time needed to clear the pipes of air may be reduced by special exhausters or accelerators. They operate simultaneously with the dry pipe valve.

This system has the same extinguishing ability as the wet pipe system; however, it is more complex and costly. It is installed where freezing temperatures are expected.

The piping and equipment used for an automatic sprinkler system must give the desired performance under any weather conditions. The National Board of Fire Underwriters and similar organizations have established certain rules that should be followed when installing a fire protection system.

Automatic sprinkler systems are usually installed by plumbers under the supervision of an engineer.

Domestic water supplies generally serve for firefighting purposes. The usual sources of supply are water distribution systems, gravity tanks, and reservoirs. In some installations, two or more independent water supplies may be provided for greater reliability.

The pipes and fittings used for fire protection systems should be suitable for the particular service conditions. Where corrosive conditions exist, consideration should be given to the use of pipes, fittings, and hangers that resist corrosion.

The pipes and fittings should be designed to withstand the working pressure of the system. When the system is installed, it should be given a hydrostatic test. This test is performed by applying water pressure equal to 1½ times the system's normal operating pressure with a controllable pressure pump.

Whenever there is an occasion to change sprinkler heads, the water must be shut off. A valve that controls the water for a certain section of the building is usually placed in an accessible location. When the water is shut off, the sprinkler head may be unscrewed from the water supply pipe and the new one installed. The pipes, valves, and sprinkler heads should be checked periodically for corrosion.

*Deluge systems.* Deluge systems are fire protection systems that deliver large quantities of water for the purpose of extinguishing a fire or to cool off equipment. These systems may deliver as much as 1000 gallons of water per minute.

Deluge systems are usually controlled by some type of sensors. One type of sensor consists of a sealed tube which contains air. This tube operates on pressure created when it is exposed to a rapid temperature rise. A rapid rise in temperature expands the air in the tube quickly, which in turn builds up pressure rapidly. This action trips a water valve which floods the affected part of the installation with water. However, a gradual increase in temperature does not operate the valve.

There are several types of deluge systems. They vary from those used in commercial buildings to those found in missile sites. Deluge nozzles vary in design, depending upon the cooling that they must perform. Most deluge nozzles are full open at all times. Deluge nozzles require very little maintenance. When they become damaged they should be replaced. Usually the nozzles are installed by screwing them into a pipe fitting, or they may be bolted by a flange arrangement.

*Standpipe systems.* Standpipes, as shown in figure 7-9, provide a constant source of water for first aid firefighting. They are designed to be used at all floor levels by either building occupants or the fire department, but should not be relied upon for total extinguishment of a fire. They improve the protection of excessively high buildings and poorly accessible areas.

Standpipe systems are classified as follows:

- Wet pipe systems with open supply valve and water pressure maintained at all times.
- Dry pipe systems which automatically admit water by opening a hose valve.
- Dry pipe systems activated by manual operation of remote-controlled devices at each hose station.
- Dry pipe systems supplied through external fire department pumper connections.
- Standpipe hose will be of 1½- or 2½-inch unlined linen in 50-foot lengths.

**Exercises (468):**

Choose the correct statements by placing a C in the spaces provided for those that are correct.

1. ____ The wet pipe fire protection system is the simplest and least expensive.
2. ____ The dry pipe system is installed where freezing temperatures are expected.
3. ____ Fire systems are tested at three times their working pressure.
4. ____ The deluge system may deliver up to 1000 gallons of water per minute.
5. ____ The deluge system nozzles are in the closed position when not in use.
6. ____ Standpipe hoses should be ½ to 2½ inches in diameter and made of unlined linen.

**469. From a list of statements concerning maintenance of interior fire protection systems, pick those that are correct.**

**Maintenance of Interior Fire Protection Systems.** Interior fire protection systems require very little maintenance, but they should be checked periodically for defective parts.

Most maintenance will consist of replacing broken sprinkler heads. To replace the heads on the wet and dry pipe systems, you have to deactivate the system. The fire department and the building custodian must be notified before the system goes down for any maintenance. You should make certain the replacement sprinkler head is the exact type of the one being replaced. Each system is designed to meet a specific need. You surely wouldn't want to replace a 120° melting fuse with a 200° fuse. This would defeat the purpose of the system.

The air compressor for a dry pipe system should be checked regularly to insure proper operation. If for some reason the system loses its air, it will fill with water, making it vulnerable to freezing temperatures. The clapper valve should be cleaned when deemed necessary and worn parts replaced.

The heat sensors should be checked at scheduled intervals on the deluge systems and any defective parts replaced. Also, the water reservoirs should be kept full at all times.

The maintenance on standpipe systems will consist of replacing old hoses and defective hose connections.

**Exercises (469):**

Pick the correct statements by placing an X in the appropriate space(s).

1. ____ To replace sprinkler heads on the wet and dry pipe systems, you will have to deactivate the system.
2. ____ You should notify the base commander before deactivating a fire system for maintenance.
3. ____ Defective sprinkler heads should be replaced with like items.
4. ____ The heat sensors on deluge systems never need checking.
5. ____ Maintenance on standpipe systems will consist of replacing the hoses and hose connections.

## 7-2. Lawn Sprinkler Systems

To keep a lawn fresh and beautiful, water is required. Rainfall, which is preferred, cannot always be counted on to deliver adequate amounts of water at the proper time. Continued long, hot summer weather with little rainfall can destroy or ruin a beautiful lawn, unless nature's supply of moisture can be supplemented at the proper time. To supplement the water supplied by nature, you use a lawn sprinkler system.

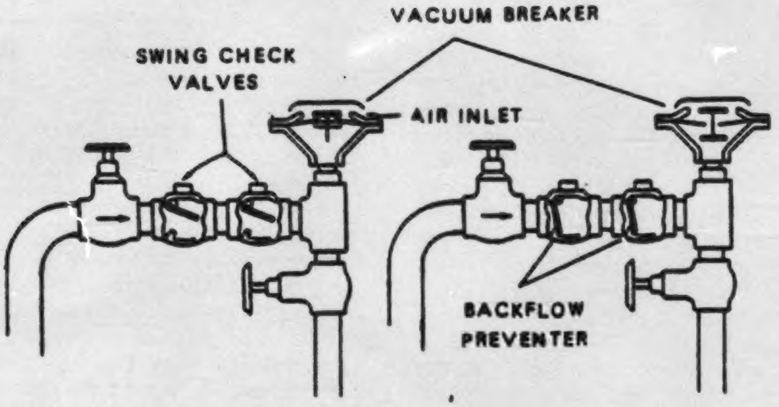

Figure 7-10. Combination backflow preventer and vacuum breaker.

**470. Given a list of statements pertaining to the installation of lawn sprinkler systems, choose those that are correct.**

**Installation of Lawn Sprinkler Systems.** Like all other plumbing systems, lawn sprinkler systems must be installed using good plumbing practices and codes. The water source for a lawn sprinkler system can be either domestic, a stream, or lake. At no time should the domestic water system be connected to a nonpotable water source. When the domestic water supply is used as the source of a lawn sprinkler system, there must be a combination backflow preventer and vacuum breaker installed on the outlet side of the sprinkler system's main control valve as illustrated in figure 7-10. This will prevent the possibility of contamination due to pressure loss in the supply system. At the same time, it will permit the sprinkler system to drain through the automatic drain valve, which should be installed in the system at its lowest point.

The types of piping that can be used for lawn sprinkler systems are copper, galvanized iron/steel, or plastic. With the improvements over the past years in plastic, it is the most economical.

The minimum depth of a system will be at least 18 inches. Any piping that contains water the year around should be installed below the frost line. When plastic piping is used, the trench should be free of stones and other debris.

The type of sprinkler heads to be used will be determined by the engineers at the time the plans are drawn. There are many types and designs of sprinkler heads; for instance, the pop-up, stationary, and oscillating. Their range is from one-eighth of a circle to full circle. The oscillating head is used for large areas like golf courses and parks; whereas the pop-up and stationary types are used in close areas.

**Exercises (470):**

Choose the correct statements by placing a checkmark (√) in the appropriate spaces.

____ 1. Lawn sprinkler systems can get their water supply from either a lake, stream, or domestic source.

____ 2. A combination backflow preventer and vacuum breaker should be installed on the outlet side of the main control valve of a lawn sprinkler when the domestic water supply system is its source of supply.

____ 3. Copper is the most economical pipe used for sprinkler systems.

____ 4. The minimum depth a sprinkler system's piping can be installed is 18 inches.

____ 5. Sprinkler heads range from one-sixteenth to a full circle.

**471. From a given list of statements related to maintenance of lawn sprinkler systems, select those that are correct.**

**Maintenance of Lawn Sprinkler Systems.** Lawn sprinkler systems require very little maintenance. Most of the maintenance is due to damage from lawn mowers and careless vehicle operators.

Each spring the systems should be checked to make sure they are in proper working order. Damaged heads should be repaired or replaced as needed. Visually, but indirectly, inspect the piping by walking the line while the pressure is on. Any leaks will usually cause a saturated area on the ground. When this is found, you should turn the system off and make the necessary repairs. Flexible plastic piping which is used on golf courses can be repaired by cutting the ruptured section out and replacing it with a new section of pipe, two couplings, and two stainless steel clamps.

Metal pipe can be repaired by cutting out the bad section and replacing it with new pipe, using a union or compression coupling to make your final connection.

**Exercises (471):**

Select the correct statements by placing a C in the appropriate spaces.

1. ___ Lawn sprinkler systems should be checked each spring for proper operation.
2. ___ Flexible plastic piping can be repaired only with stainless steel couplings.
3. ___ When repairing lawn sprinkler systems which are constructed with metal piping, the final connection may be made with a compression coupling.
4. ___ Only one stainless clamp is needed to make a repair on flexible plastic piping which is ruptured.

# Answers for Exercises

## CHAPTER 1

**Reference:**

400 - 1.

---

Figure 1. Answer for objective 400, exercise 1.

400 - 2. Quantity and quality of water needed.
400 - 3. Domestic and industrial.
400 - 4. Flanged, threaded, and mechanical couplings.

401 - 1. Foundation plan; floor plan; roof plan; front, rear, and side elevations; and a plot plan which shows the location of the building on the lot.
401 - 2. A working drawing or sketch of the job.
401 - 3. Faucets.
401 - 4. No connection.
401 - 5. You generally take about 30 percent of the maximum fixture demand.
401 - 6. Shutoff valves.

402 - 1. T.O.
402 - 2. ____
402 - 3. ____
402 - 4. T.O.
402 - 5. ____
402 - 6. T.O.
402 - 7. ____

403 - 1. ✓
403 - 2. ✓
403 - 3. ____
403 - 4. ✓
403 - 5. ✓

404 - 1. T
404 - 2. F
404 - 3. T
404 - 4. T

405 - 1. b
405 - 2. a
405 - 3. a

406 - 1. TWM
406 - 2. ____
406 - 3. TWM
406 - 4. TWM
406 - 5. ____
406 - 6. TWM

407 - 1. T
407 - 2. ____
407 - 3. ____
407 - 4. T

408 - 1. M
408 - 2. DWV
408 - 3. L
408 - 4. K

409 - 1. T
409 - 2. F
409 - 3. T
409 - 4. T
409 - 5. T
409 - 6. F

410 - 1. d, c, a, b
410 - 2. The fire department.
410 - 3. A diaphragm pump.

411 - 1. T
411 - 2. T
411 - 3. F
411 - 4. T
411 - 5. F
411 - 6. T
411 - 7. F
411 - 8. T
411 - 9. T
411 - 10 T
411 - 11. T
411 - 12. F

## CHAPTER 2

412 - 1. a. Types of flush devices used.
b. Pressure of water supply.
c. Length of piping.
d. Number of fixtures.
e. Probable use factor of fixtures.
412 - 2. Friction.
412 - 3. Increase the size of pipe.

413 - 1. Between the curb and sidewalk.
413 - 2. At 10-foot intervals or closer.
413 - 3. With 2" x 4" headers.
413 - 4. At each floor level.
413 - 5. Pipe rest or clamps.
413 - 6. An air chamber, which can be made with a tee, a piece of pipe, and a cap.
413 - 7. Caps.

414 - 1. T
414 - 2. _____
414 - 3. T
414 - 4. _____
414 - 5. T
414 - 6. T

415 - 1. C
415 - 2. C
415 - 3. _____

416 - 1. _____
416 - 2. C
416 - 3. C
416 - 4. C

417 - 1. Two.
417 - 2. 24 inches.
417 - 3. 1/2 inch.
417 - 4. 1 inch.
417 - 5. Manufacturer's specification sheet.

418 - 1. C
418 - 2. _____
418 - 3. C
418 - 4. C
418 - 5. _____
418 - 6. C

419 - 1. d
419 - 2. c
419 - 3. a
419 - 4. b

420 - 1. ✓
420 - 2. _____
420 - 3. ✓
420 - 4. ✓
420 - 5. _____
420 - 6. ✓

421 - 1. Floor-mounted and wall-hung.
421 - 2. Chair carrier.
421 - 3. a. Washdown.
b. Washdown with jet.
c. Reverse trap.
d. Siphon jet.
421 - 4. The float valve.
421 - 5. Closet flange.
421 - 6. Jiffy connector.
421 - 7. 10 seconds.
421 - 8. Force cup or closet auger.

422 - 1. T
422 - 2. T
422 - 3. _____
422 - 4. T
422 - 5. _____

423 - 1. C
423 - 2. C
423 - 3. _____
423 - 4. C
423 - 5. _____
423 - 6. _____
423 - 7. C

424 - 1. ✓
424 - 2. ✓
424 - 3. _____
424 - 4. ✓

425 - 1. Start at the highest point in the system by removing a fixture and start with the risers.
425 - 2. Cut the pipe and unscrew it from both directions.
425 - 3. Ballpeen hammer and pickout iron.
425 - 4. Gloves and goggles.
425 - 5. At the tip of the inner cone.

426 - 1. ✓
426 - 2. _____
426 - 3. _____
426 - 4. ✓
426 - 5. ✓
426 - 6. ✓
426 - 7. ✓

## CHAPTER 3

427 - 1. 32.
427 - 2. It should be annealed.
427 - 3. To allow vibrations, expansion, and contraction.
427 - 4. It is easily disassembled when it becomes necessary to make repairs.
427 - 5. The wall thickness of the tubing.
427 - 6. 3000 pounds per square inch.
427 - 7. By soldering.

428 - 1. ✓
428 - 2. _____
428 - 3. ✓
428 - 4. ✓
428 - 5. _____
428 - 6. ✓
428 - 7. ✓

## CHAPTER 4

429 - 1. C
429 - 2. C
429 - 3. ____
429 - 4. C
429 - 5. ____

430 - 1. d
430 - 2. a
430 - 3. b
430 - 4. e
430 - 5. c

431 - 1. C
431 - 2. ____
431 - 3. C
431 - 4. C
431 - 5. C
431 - 6. ____

432 - 1. Waterproof paste.
432 - 2. The same type insulation as that used on the rest of the system.
432 - 3. They should be tightened.

433 - 1. T
433 - 2. ____
433 - 3. T
433 - 4. T
433 - 5. ____
433 - 6. T
433 - 7. T

434 - 1. The highest faucet.
434 - 2. By flushing and sopping with a sponge or rag.
434 - 3. The union.
434 - 4. Antifreeze.
434 - 5. With a suction pump, or by siphoning the water with a small hose.

## CHAPTER 5

435 - 1. X
435 - 2. X
435 - 3. ____
435 - 4. ____
435 - 5. X
435 - 6. X
435 - 7. ____

436 - 1. c
436 - 2. d
436 - 3. a
436 - 4. f
436 - 5. b
436 - 6. e

437 - 1. c, a, e, b, d

438 - 1. X
438 - 2. ____
438 - 3. X
438 - 4. X
438 - 5. ____

439 - 1. The single- and double-tank types.
439 - 2. 180° F.

440 - 1. C
440 - 2. ____
440 - 3. C
440 - 4. ____

441 - 1. Manufacturer's instructions.
441 - 2. The operator.
441 - 3. The plumber.

442 - 1. ____
442 - 2. T
442 - 3. ____
442 - 4. T

443 - 1. ____
443 - 2. C
443 - 3. ____
443 - 4. C

444 - 1. Each day.
444 - 2. The steam valve.
444 - 3. Once a year.

445 - 1. ____
445 - 2. T
445 - 3. ____
445 - 4. T

446 - 1. Soft blue.
446 - 2. Until it just touches the kettle.
446 - 3. Every week.

447 - 1. T
447 - 2. ____
447 - 3. ____
447 - 4. T

448 - 1. C
448 - 2. C
448 - 3. I
448 - 4. I

449 - 1. Enameled steel, enameled cast iron, and stainless steel.
449 - 2. 36 inches.
449 - 3. The selection of a suitable faucet, its installation on the sink, and the connection of the water supply.
449 - 4. Force cup.

450 - 1. C
450 - 2. ____
450 - 3. C
450 - 4. C
450 - 5. ____

451 - 1. T
451 - 2. ____
451 - 3. T
451 - 4. ____
451 - 5. T

452 - 1. ____
452 - 2. C
452 - 3. C
452 - 4. C
452 - 5. ____

453 - 1. X
453 - 2. ____
453 - 3. X
453 - 4. ____
453 - 5. X

454 - 1. C
454 - 2. ____
454 - 3. C
454 - 4. ____
454 - 5. C
454 - 6. C

455 - 1. They are used to record the amount of water that is used by a consumer.
455 - 2. Usually just inside the basement wall.
455 - 3. Cast iron.
455 - 4. It should be replaced with a new or reconditioned unit.

456 - 1. T
456 - 2. ____
456 - 3. T
456 - 4. T
456 - 5. ____

457 - 1. C
457 - 2. ____
457 - 3. C
457 - 4. ____
457 - 5. C
457 - 6. C

## CHAPTER 6

458 - 1. C
458 - 2. C
458 - 3. ____
458 - 4. ____
458 - 5. C
458 - 6. C

459 - 1. c
459 - 2. a
459 - 3. b
459 - 4. e
459 - 5. d

460 - 1. X
460 - 2. X
460 - 3. ____
460 - 4. X
460 - 5. X
460 - 6. ____
460 - 7. X
460 - 8. ____

461 - 1. b
461 - 2. c
461 - 3. a

462 - 1. T
462 - 2. T
462 - 3. ____
462 - 4. ____
462 - 5. T
462 - 6. T

463 - 1. c
463 - 2. d
463 - 3. b
463 - 4. a

464 - 1. T
464 - 2. ____
464 - 3. T
464 - 4. T

465 - 1. ____
465 - 2. X
465 - 3. X
465 - 4. X

## CHAPTER 7

466 - 1. c
466 - 2. e
466 - 3. a
466 - 4. h
466 - 5. b
466 - 6. d
466 - 7. g
466 - 8. f

467 - 1. X
467 - 2. X
467 - 3. ____
467 - 4. ____
467 - 5. X

468 - 1. C
468 - 2. C
468 - 3. ____
468 - 4. C
468 - 5. C
468 - 6. C

469 - 1. X
469 - 2. ____
469 - 3. X
469 - 4. ____
469 - 5. X

470 - 1. ✓
470 - 2. ✓
470 - 3. ____
470 - 4. ✓
470 - 5. ____

471 - 1. C
471 - 2. ____
471 - 3. C
471 - 4. ____

295

**STOP–** **1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.** **2. USE NUMBER 1 OR NUMBER 2 PENCIL.**

55255 03 21

# EXTENSION COURSE INSTITUTE
# VOLUME REVIEW EXERCISE
# WATER SUPPLY SYSTEMS AND FIXTURES

Carefully read the following:

*DO'S:*

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that numerical sequence on answer sheet alternates across from column to column.
3. Use a medium sharp #1 or #2 black lead pencil for marking answer sheet.
4. Circle the correct answer in this test booklet. After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

*DON'TS:*

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #1 or #2 black lead pencil.

*NOTE:* NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers.* The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed.* Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

## Multiple Choice

1. (400) What type of pump is used to increase water pressure in a distribution system?

   a. Circulating.
   b. Booster.
   c. Sump.
   d. Diaphragm.

2. (400) Which type valve is used to restrict the flow on a small service line?

   a. Check.
   b. Curb.
   c. Globe.
   d. Pressure-reducing.

3. (400) What type valve serves as a positive shutoff on a fire hydrant?

   a. Branch.
   b. Gate.
   c. Secondary.
   d. Master.

4. (400) What is the difference between making a lead joint and a sulfur joint?

   a. The sulfur is not heated.
   b. Lead requires a special oakum.
   c. No caulking is required on a sulfur joint.
   d. The lead joint requires no special tools.

5. (400) Which method of assembling pipe requires a gasket?

   a. Flange.
   b. Compression.
   c. Union.
   d. Threaded.

6. (401) What percent of the maximum fixture demand is used as a general rule for estimating the probable demand for small residences?

   a. 10 percent.
   b. 20 percent.
   c. 30 percent.
   d. 40 percent.

7. (402) Which of the following is a tabulated list of requirements for a job?

   a. Blueprint.
   b. Identification ticket.
   c. Takeoff sheet.
   d. Bill of materials.

8. (403) What function does a corporation stop serve in a building water supply system?

   a. Inactive pipe end.
   b. Accessible shutoff inside the building.
   c. Takeoff point from the street water main.
   d. Split section takeoff between the curb stop and the building.

9. (404) What is the largest opening that can be made with a self-tapping machine while the main is under pressure?

   a. 1 inch.
   b. 2 inches.
   c. 3 inches.
   d. 4 inches.

10. (405) What is used to protect a corporation stop from strain or damage?

    a. An expansion loop.
    b. A flexible connection.
    c. A line block.
    d. A perforated tape.

11. (406) Which is the best type of pipe to use when installing a 24-inch temporary water main?

a. Vitrified clay.
b. Galvanized.
c. Cast iron.
d. Asbestos cement.

12. (407) Which type coupling is used on a small steel pipe when a temporary main must be installed in a hurry?

a. Compression.
b. Quick twist.
c. Snap clips.
d. Threaded.

13. (407) Which tool is required when installing asbestos sleeve couplings?

a. Hub clamp.
b. Pipe jack.
c. Torque wrench.
d. Snatch block.

14. (408) What is the standard length of hard-drawn copper tubing?

a. 5 feet.
b. 10 feet.
c. 15 feet.
d. 20 feet.

15. (408) Which type copper tubing is identified by the color red?

a. K.
b. L.
c. M.
d. DMV.

16. (410) What base organization must be notified any time a water main is turned off?

a. Industrial engineering.
b. Equipment section.
c. Security police.
d. Fire department.

17. (410) Which type pump is used to remove water, mud, and rocks from an excavation?

a. Centrifugal.
b. Diaphragm.
c. Pneumatic.
d. Hydraulic.

18. (411) What controls the closing of the valve in the piston-type flushometer valve?

a. Bypass.
b. Diaphragm.
c. Relief.
d. Solenoid.

19. (411) Which part of a gate valve holds the packing that seals the bonnet against leaks around the stem?

a. Disc press.
b. Shaft ring.
c. Valve seat.
d. Stuffing box.

20. (411) Which type valve is used on a hot water tank to prevent hot water from backing up in the cold water line?

a. Ream.
b. Check.
c. Quick-way.
d. Master control.

21. (412) Pipe friction in a water supply system

a. creates bubbles.
b. causes a drop in water pressure.
c. causes rapid pipe wear.
d. increases water velocity.

22. (413) What is installed in a water system to eliminate water hammer?

a. An air chamber.
b. A quick-closing valve.
c. Vertical stop plates.
d. Flexible connections.

23. (414) What fastening devices are used to attach a mounting bracket to a concrete wall?

a. Steel nuts and bolts.
b. Masonry and common nails.
c. Lead sleeves and brass screws.
d. Plastic inserts and steel screws.

24. (415) At what height in inches above the rough floor line will the center of a mixing faucet for a bathtub be installed?

a. 12 inches.
b. 18 inches.
c. 24 inches.
d. 30 inches.

25. (417) What size supply line should be installed for a tank-type water closet?

a. 1/2 inch.
b. 3/4 inch.
c. 1 inch.
d. 1 1/2 inches.

26. (418) Unless otherwise specified, how high is the overflow rim of a wall-hung lavatory installed above the finished floor?

a. 25 inches.
b. 27 inches.
c. 31 inches.
d. 33 inches.

27. (419) What minimum size waste pipe is sufficient for drinking fountains?

a. 3/4 inch.
b. 1 inch.
c. 1 1/4 inches.
d. 1 1/2 inches.

28. (420) Which of the following mixing valves assures the most constant temperature to a shower head?

a. Pressure mixing valve.
b. Compound mixing valve.
c. Manual mixing valve.
d. Thermostatic mixing valve.

29. (421) Which of the following water closet bowls is most efficient?

a. Washdown.
b. Washdown with jet.
c. Reverse trap.
d. Siphon jet.

30. (421) Which method is best when replacing a water closet bowl on a floor that has been raised above the top of the closet bend flange?

a. Raise the flange.
b. Use two wash rings.
c. Increase the compound.
d. Install adapter.

31. (421) What is the maximum setting time for the diaphragm type flush valve?

a. 5 seconds.
b. 10 seconds.
c. 15 seconds.
d. 20 seconds.

32. (422) Which mechanism discharges a predetermined quantity of water directly from the supply line to a urinal?

a. Aquaflow.
b. Douglas valve.
c. Flushometer.
d. Pulsator.

33. (423) When testing a low-pressure system, how many pounds of air is added to the working pressure of the system?

a. 0 to 25 pounds.
b. 25 to 50 pounds.
c. 50 to 75 pounds.
d. 75 to 100 pounds.

34. (424) If quick draining of a water system is required, the highest faucet in the system should be

a. open and the lowest faucet should be open.
b. closed and the lowest faucet should be closed.
c. closed and the lowest faucet open.
d. open and the lowest faucet closed.

35. (425) Which type of wrench is best to use when disassembling chromium pipes?

a. Pipe.
b. Water pump.
c. Basin.
d. Strap.

36. (425) What point on an oxyacetylene torch produces the greatest amount of heat?

a. Center of the inner cone.
b. Tip of the inner cone.
c. Center of the outer cone.
d. Tip of the outer cone.

37. (425) What would be the most logical method to use in disassembling a plumbing system?

a. Start at the highest point in the system.
b. Start at the lowest point in the system.
c. Start at the center of the system and work both ways.
d. Start with the largest section of the system.

38. (426) What action is taken when an inspection reveals stripped and damaged threads on a pipe section?

a. Reshape with a threader.
b. Cut off the damaged area and rethread.
c. Install a sleeve.
d. Discard the section.

39. (427) What is the maximum angle copper tubing can be bent with a tube bender?

a. 45°.
b. 90°.
c. 120°.
d. 180°.

40. (427) What additional item is required when flaring copper tubing with a flaring plug?

a. Butt plate.
b. Hacksaw.
c. Hammer.
d. Center set.

41. (427) How is a swaged joint sealed?

a. By soldering.
b. By brazing.
c. By flaring and fitting.
d. With a jiffy connector.

42. (428) Which tool is recommended for cutting copper pipe over 2 inches in diameter?

a. Tube cutter.
b. Hacksaw.
c. Knife cutter.
d. Three-wheel pipe cutter.

43. (429) What is the primary reason for insulating hot water lines?

a. Reduce noise.
b. Limit condensation.
c. Prevent cold air from contacting pipe.
d. Prevent heat loss from the hot water.

44. (430) When covering a brine system, which of the following coverings is best?

a. Cork.
b. Flex rubber.
c. Sponge felt paper.
d. Wool felt.

45. (430) Which of the following is an excellent material to insulate high-pressure steam lines?

a. Anti-sweat.
b. Fiberglass.
c. Magnesia.
d. Air cell.

46. (431) What is done to iron pipe before flex rubber insulation is installed?

a. Cheesecloth is wound around the pipe.
b. It is painted with glossy enamel.
c. It is painted with an asphalt base primer.
d. A heavy grease is brushed on it.

47. (432) After repair is made to an insulated system, what type of insulation is installed over the repaired area?

a. An asbestos liner.
b. A fiberglass patch kit.
c. Quick set plaster.
d. The same type as is used on the rest of system.

48. (433) From the standpoint of speed, safety, and economy, which is the best method of thawing frozen water pipes?

a. With chemicals.
b. With a torch.
c. With electricity.
d. With boiling water.

49. (434) What is used when winterizing a waste system to prevent sewer gas from entering the building?

a. Glycerin and water.
b. Mineral spirits.
c. Caustic soda.
d. Sodium hydroxide.

50. (435) What are the positions of the automatic burner valve during operation of a gas water heater?

a. From 1/4 on to full on.
b. From off to 3/4 on.
c. Full off or full on.
d. Varying between full off and full on.

51. (436) For increased efficiency, where should a water heater be located?

a. In a small room that is insulated with a vapor barrier.
b. As close as possible to hot water risers.
c. In a well ventilated area.
d. Close to the fuel source.

52. (436) What is the estimated amount of hot water used per person per hour in a barracks?

a. 1 to 2 gallons.
b. 3 to 4 gallons.
c. 5 to 6 gallons.
d. 8 to 10 gallons.

53. (436) What type of valve should be used on the cold water supply line to the water heater?

a. Gate.
b. Plug.
c. Angle.
d. Globe.

54. (436) In order to detect gas leaks, the plumber might add which of the following to the gas?

a. Smoke.
b. Garlic.
c. Liquid soap.
d. Peppermint.

55. (437) The thermostat of a water heater should be set at how many degrees for ordinary use?

a. 100° F.
b. 140° F.
c. 180° F.
d. 200° F.

56. (438) The storage tank of a water heater should be flushed every

a. 3 months.
b. 6 months.
c. 12 months.
d. 18 months.

57. (439) What is the most important component of the dishwasher?

a. Strainer trays.
b. Overflow pipes.
c. Water mixing valve.
d. Hot water booster.

58. (440) When inspecting a dishwasher in which gas is the source of heat, what test should you use to check the gas pipes and fittings for leakage?

a. The soap test.
b. The sound test.
c. The match test.
d. The peppermint test.

59. (440) What component is installed in a dishwasher system that has a steam heated water booster?

a. Pressure relief valve.
b. Condensate return trap.
c. Superheated injector needle.
d. Dual tube saturator.

60. (441) Who has the responsibility of keeping the dishwasher screens clean and free of debris?

a. Operator.
b. Plumbing specialist.
c. Environmental support specialist.
d. Dishwasher maintenance technician.

61. (442) Which of the following steam pressures would be best for the operation of a steam kettle?

a. 15 psi.
b. 35 psi.
c. 105 psi.
d. 215 psi.

62. (443) If the steam pressure source is higher than the working pressure of a steam kettle, what should you do?

a. Call the source and ask that they reduce the pressure.
b. Install an orifice in the steam line two feet from the kettle.
c. If the pressure is less than double the working pressure, take no action.
d. Install a pressure reducing valve in the steam inlet line near the kettle.

63. (443-445) What type of kitchen equipment should be in a depressed floor area near a floor drain?

a. Dishwasher.
b. Water heater.
c. Scullery sink.
d. Steam kettle.

64. (444) What equipment requires cleaning the interior surfaces and strainer with soap and water each time it is used?

a. Steam kettle.
b. Water heater.
c. Scullery sink.
d. Dishwasher.

65. (446) The burner flame color of a gas-heated steam kettle should be

a. blue-yellow.
b. yellow-blue.
c. soft blue.
d. soft yellow.

66. (447) Who should install the switches and circuit breakers during installation of an electrically heated steam kettle?

a. Qualified electrician.
b. Plumbing foreman.
c. Plumbing specialist.
d. Supervisor on the job.

67. (448) What is the maximum thermostat setting allowed for an electrically heated steam kettle?

a. 212° F.
b. 285° F.
c. 350° F.
d. 425° F.

68. (449) When installing kitchen sinks, what is the distance between the floor and the top of the drainboard in inches?

a. 24.
b. 30.
c. 33.
d. 36.

69. (450) What should be done to prevent a utility sink from sagging?

a. Adjust the hanger.
b. Unscrew the legs.
c. Adjust the stand trap.
d. Place a wedge under the pedestal.

70. (451) In a mess facility, what sink is used to wash vegetables, greasy pots, and pans?

a. Service.
b. Utility.
c. Kitchen.
d. Scullery.

71. (452) How is a laundry tub leveled if it doesn't have leveling bolts at the bottom of the legs?

a. The hanger height is adjusted.
b. The legs are shimmed.
c. The stand trap is shimmed.
d. A wedge is placed under the pedestal.

72. (453) What is the approximate steam working pressure (psi) for laundry presses and ironers?

a. 15 psi.
b. 40 psi.
c. 75 psi.
d. 100 psi.

73. (454) What maintenance may be performed while a water pump is operating?

a. Tightening the pump packing to prevent excessive leakage.
b. Adjusting the flexible coupling.
c. Removing a defective impeller.
d. Replacement of the pump packing.

74. (455) When a water meter fails to operate, what action does the plumbing specialist take?

a. He shuts off the water supply to the customer.
b. He repairs the water meter just as fast as he can.
c. He fabricates a bypass connection and reports the failure to the meter reader.
d. He removes the defective meter and replaces it with a new or reconditioned meter.

75. (456) When does the pneumatic sewage ejector begin its operation cycle?

a. When it is placed in operation as it runs continuously.
b. When the pot is full and pressure is exerted on the check valve.
c. When the sewage lever raises up to the upper electrode.
d. When the pressure on the check valve overrides the valve spring pressure.

76. (457) When using air for pneumatic controls and instruments, the air

a. pressure must be highly variable.
b. must be clean and dry.
c. must vary in relative humidity from 50 to 15 percent.
d. must possess the characteristic of medium to high compressability.

77. (457) What type connections should you use for copper tubing used in pneumatic and vacuum lines?

a. Flared.
b. Threaded.
c. Welded.
d. Soldered.

78. (458) What inspection do you perform first when inspecting a plumbing installation?

a. Leaks.
b. Visual.
c. Corrosion.
d. Pipe alignment.

79. (458) A pipe is leaking on one floor and seeping to the level below. What is probably the best method of finding the leak?

a. Visual inspection.
b. Wear a white glove and run your hand along the pipe.
c. Turn the water off and on several times as a helper observes the pipe.
d. Place one end of a piece of wood against your ear and the other end against the pipe and trace the sound.

80. (458) What usually causes stripped threads on pipe fittings?

a. Inferior product.
b. Unskilled worker.
c. Cross-threading.
d. Improper tools.

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81. (458) When making an emergency repair to an underground 2-inch cold water steel pipe that has a 1-inch long crack, what is the best repair item that you could use?

a. A wood plug.
b. A pipe clamp.
c. Iron cement.
d. A sheet metal screw.

82. (459) Corrosion which occurs as the result of direct chemical attack is called

a. uniform corrosion.
b. localized corrosion.
c. bacterial corrosion.
d. dissimilarity corrosion.

83. (459) Localized corrosion is the result of

a. direct chemical attack.
b. electrolytic action.
c. soil conditions.
d. mill scale.

84. (459) What is the most logical method used to reduce microbiological corrosion?

a. Painting the metal surface.
b. Spraying the bacteria.
c. Shocking the bacteria with an electric current.
d. Vibrating the metal with a vibrator at regular timed intervals.

85. (460) Which of the following metals is most likely to be affected by corrosion?

a. Steel.
b. Brass.
c. Monel.
d. Copper.

86. (460) Which of the following pipe materials is most affected by corrosion?

a. Plastic.
b. Cast iron.
c. Vitrified clay.
d. Asbestos cement.

87. (461) Which type coating is the most common for corrosion protection?

a. Paint.
b. Rubber.
c. Asphalt.
d. Coal tar.

88. (461) What ingredient mixture is used for concrete to be used as a coating on a pipeline?

a. One part cement to two parts sand.
b. Two parts cement to one part sand.
c. One part cement to two parts sand to three parts gravel.
d. Two parts cement to three parts sand to five parts gravel.

89. (462) What means is used to protect metal structures from corrosion?

a. Electromagnetism.
b. Preventive painting.
c. Galvanic cathode protection.
d. Electronic synthesis.

90. (462) How does galvanic cathodic protection control corrosion?

a. It stops the positive current flow.
b. It stops the negative current flow.
c. It coats the corrosive metal area with zinc.
d. By changing direct current to alternating current.

91. (462) When the galvanic anode method is used to prevent corrosion of iron pipe, what metal is used as the sacrificial anode?

a. Iron.
b. Nickel.
c. Magnesium.
d. Aluminum.

92. (463) What instrument is used to locate buried pipe?

a. Voltmeter.
b. Ampmeter.
c. Hydraulic pipe locator.
d. Electronic pipe locator.

93. (464) How much magnesium is wasted away by electrolysis from an anode per ampere year?

a. 7.
b. 17.
c. 27.
d. 57.

94. (465) What values of voltage are used in the impressed current system of cathodic protection?

a. 110- to 220-volts DC.
b. 110- to 220-volts AC.
c. 12- to 40-volts DC.
d. 12- to 40-volts AC.

95. (466) Which type fire hydrant features breakaway bolts?

a. Traffic.
b. Flush.
c. Standard.
d. Above ground.

96. (466) What is the diameter of the pumper nozzle on a fire hydrant?

a. 1 inch.
b. 2 inches.
c. 3 inches.
d. 4 inches.

97. (466) How far apart are fire hydrants usually placed in housing areas?

a. 100 feet.
b. 200 feet.
c. 400 feet.
d. 800 feet.

98. (466) The highest operating nut of a fire hydrant can be a maximum of

a. 10 inches above ground.
b. 25 inches above ground.
c. 4 feet above ground.
d. 6 feet above ground.

99. (467) How often should fire hydrants be inspected to determine maintenance requirements?

a. Monthly.
b. Quarterly.
c. Semiannually.
d. Annually.

100. (467) Where should you start your inspection of the base fire hydrants?

a. At the base civil engineering organization.
b. At family housing.
c. At the base water supply source.
d. At the hydrant bearing the smallest identification number.

101. (467) A record on each fire hydrant should be maintained on AF Form

a. 995.
b. 1050.
c. 1846.
d. 2020.

102. (467) A velocity pressure check of fire hydrants is made by

a. the plumbing shop only.
b. the environmental support group.
c. the fire department only.
d. the plumbing shop and the fire department jointly.

103. (467) The fire hydrant continues to drain after the main valve is turned off. How can you tell if the main valve is leaking?

a. Make a visual check.
b. Listen for the sound of rushing water.
c. Use a leak detector tester.
d. Use a chemical tester.

104. (468) Which is the simplest and least expensive interior fire protection system?

a. Deluge.
b. Standpipe.
c. Wet pipe.
d. Dry pipe.

105. (469) What is the most common maintenance problem of the interior fire protection system?

a. Replacing corroded pipe.
b. Replacing broken sprinkler heads.
c. Replacing packing on auxiliary high-pressure pumps.
d. Draining water from pipes to prevent corrosion from stopping sprinkler heads.

106. (470) What is the most economical pipe for a lawn sprinkler system?

a. Plastic.
b. Copper.
c. Steel.
d. Galvanized.

107. (471) What causes most of the maintenance on a plastic lawn sprinkler system?

a. Gophers chewing on the pipe.
b. Careless lawn mower and vehicle operators.
c. Chemical action between the soil moisture and the pipe.
d. Electrolytic action between the soil moisture and the pipe.